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ABSTRACT

In 1986, the Louisiana State Board of Elementary and Secondary Education requested that an advanced course in Biology II be developed. The resulting curriculum guide contains grade appropriate goals, skills, and competencies; suggested activities; suggested materials of instruction; and minimum time allotments for instruction. Biology II is a specialized course designed for the student who has an adequate background in chemistry and general biology. This guide is developed around content cores entitled: (1) "History of Studying Biology"; (2) "Process of Biological Investigation"; (3) "Chemistry"; (4) "Cellular Biology"; (5) "Genetics and Heredity"; and (6) "Evolution." Following these domains the guide is organized into a two-tailed curriculum. One direction follows an advanced curriculum reviewing in depth the basic areas of cell biology, biochemistry, biological diversity, plant and animal physiology, metabolism and respiration, the response of organisms to the environment, behavior, and ecology. A second approach emphasizes comparative anatomy and physiology. This section places a special emphasis on the vertebrate body and how it functions. Curriculum standards and a skills checklist for 256 objectives are listed. A bibliography and evaluation techniques are provided. A total of 21 sample laboratory exercises are described in the appendix. (YP)

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STATE OF LOUISIANA
DEPARTMENT OF EDUCATION

BIOLOGY II CURRICULUM GUIDE

Bulletin 1820
1987

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STATE OF LOUISIANA

DEPARTMENT OF EDUCATION

BIOLOGY II CURRICULUM GUIDE

Bulletin 1820

1987

Issued by

Office of Academic Programs

THOMAS G. CLAUSEN, Ph.D.

Superintendent

FOREWORD

Act 750 of the 1979 Louisiana Legislature (R.S. 17:24.4) established the Louisiana Competency-Based Education Program. One of the most important provisions of Act 750 is the mandated development and establishment of statewide curricular standards for required subjects. As reenacted and redefined by Act 146 of the 1986 Legislature, these curricular standards include "curriculum guides which contain grade appropriate skills and competencies, suggested activities, suggested materials of instruction, and minimum required time allotments for instruction in all subjects."

During the 1979-80 school year, curriculum guides were developed by advisory and writing committees representing all levels of professional education and all geographic areas across the State of Louisiana for the following science courses: Elementary Science K-6, Life Science, Earth Science, Physical Science, General Science, Biology, Chemistry, and Physics. Following established curricular development procedures, these curriculum guides were piloted in 1982-83 and were implemented statewide in the fall of 1984. In 1986, a curriculum guide for Environmental Science was developed.

In 1986, the Board of Elementary and Secondary Education requested that an advanced science course in Biology II be developed. This course is designed to address the need of students desiring additional sciences.

Thomas G. Clausen

Thomas G. Clausen, Ph.D.

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PREFACE

Biology is one of the most complex of all the science fields. The growth of life sciences and the integration of new technologies has provoked a revolution. Genetic engineering, frozen embryos, and oncological research are some of the new areas that are being discussed in everyday news. Biology is not only a preparatory subject for careers in geology, medicine, horticulture, entomology, and molecular biology, but also a subject of study by the general public. Everyone relies on the same biological processes, reproduces in the same biological manner and is limited to the environment in which we live.

Biology II is a specialized course designed for the student who has an adequate background in chemistry and general biology. This guide is developed around a core of material common to all advanced biological sciences. The core initially reintroduces the scientific method, statistics and research design. Other accepted core areas or domains include: cell biology, biochemistry, genetics, reproduction and development, and evolution. Following these domains the guide is organized into a "two-tailed" curriculum. One direction follows an advanced curriculum reviewing in depth the basic areas of cell biology, biochemistry, biological diversity, plant and animal physiology, metabolism and respiration, response of organism to the environment, behavior, and ecology. A second approach emphasizes comparative anatomy and physiology. This section will place a special emphasis on the vetebrate body and how it functions. A detailed study of all vetebrate classes will be conducted. The primary mammalian systems and organs will be the major focus. Functions, descriptions, and disorders of each system and organ will be covered.

The content of this course requires that students be prepared with an adequate physical science background, especially in chemistry. It is strongly recommended that students enrolled in this course will have taken chemistry or will be concurrently enrolled in chemistry.

RATIONALE FOR TEACHING SCIENCE

INTRODUCTION

Developments in science technology have improved our way of living and have become a major influence on our culture. No one in our culture escapes the direct influence of science. Because of the impact of science on our social, economic, and political institutions, the education of every responsible citizen must include not only the basic principles of science but also the attitudes and processes of scientific thought.

The nature of science itself determines the way that it should be taught. The definition of science is a twofold one: it is (1) an unending method or process of seeking new knowledge, and (2) the body of knowledge which results from this search. Science is an intellectual, active process which involves an investigator of any age and something to investigate. The discipline of science taught by the process approach teaches the student how to learn and that intellectual gain is a permanent one for the student.

The process approach develops the intellectual abilities of students. Some students develop thinking skills in the normal course of growing up in a complex world but the acquisition of useful skills and attitudes is by no means automatic. Many students succeed in school by repeating what they are told in a slightly different form or by memorizing; such strategies are of little extended value. At present, relatively few students develop persistence in and zest for dealing with new concepts because they are not aware of their intellectual capabilities; thus, students need literally to experience the application of skills in scientific processes in different situations.

To be most effective, methods of science instruction must be based upon the development of skills in critical thinking. Guided practice in experimenting, observing, gathering information, organizing facts, and drawing conclusions will help to develop critical thinking skills. Laboratory techniques should be employed whenever possible, and inquiry teaching/learning situations using both deductive and inductive reasoning should be the predominant method used in all classroom activities. The teacher's role in a process-oriented science classroom includes being a provider of problems, a discussion leader, a supplier of clues (when necessary), and a skillful questioner, i.e., a facilitator of learning activities. Thus, the aim of an effective science program should be to equip each child with competencies in the basic processes and concepts of science through individual participation in activities and investigations specifically designed to develop such capabilities.

What is Science?

Science is defined in many different ways. Many people think that science is a body of knowledge consisting of facts, theories, and laws, and that scientists use these laws to experiment. They believe that science is something done by scientists. In addition, these people view science as a vast mysterious field, unapproachable by the average person. Science, when viewed by philosophers see it as a process of methods of deriving conclusions or explanations about natural phenomena. Teachers on the other hand often limit their definition to the content within textbooks and materials obtained from lectures. Therefore, students are limited to the definitions of science that are portrayed by their teacher, or activities, or textbooks.

These broad views of science often create confusion about what science is and why it should be taught. Basically science should be viewed as a way of thinking, a process by which explanations are derived. Within this view, four components of science emerge: problem solving, science knowledge, nature of science, and science technology and society. Problem solving is an activity inseparable from science. It includes "sequential thinking" and "trial and error." Both, when coupled, form the basis for actions, questioning, collecting data, analyzing data, and explaining the results.

This problem solving approach is conducted by anyone making sound decisions yet becomes more precise when actually conducting applied or pure scientific research. These skills are summarized in Table I.

TABLE I
Problem Solving

Questioning	Collecting Data	Analyzing Data	Explaining
Recognizing patterns	Observing	Clarifying	Describing
Recognizing parts	Measuring and quantifying	Organizing	Modeling
Recognizing discrepant events	Selecting variables	Inferring	Defining
Stating questions	Estimating	Correlating	Interpreting
Stating hypotheses	Identifying significance		Communicating

Science knowledge is based on an accumulation of investigations and conclusions. As these investigations and conclusions increased, the body of science knowledge diversified into separate conceptual areas. Seven such conceptualizations are diversity, change, continuity, interaction, organization, limitations, and interrelationships.

The nature of science is a primary component of the study of science. Three major elements are found within this component: 1) the philosophy of science--basic assumptions and accepted rules, 2) investigations of scientists--methodology used by scientists, and 3) the history of science--evolution of science.

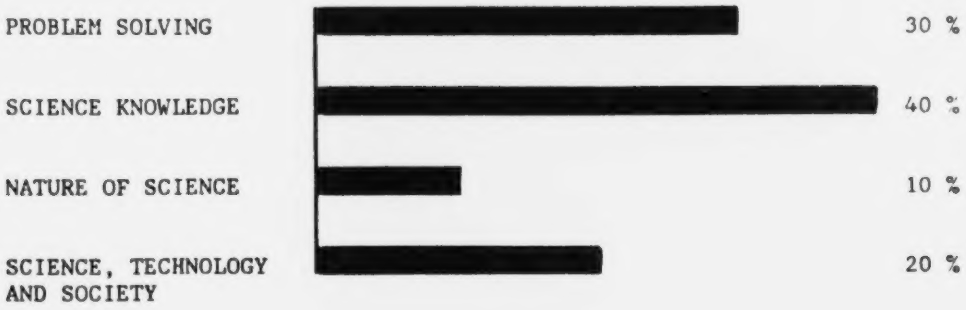
Understanding how current science was developed provides a basis for understanding trends and predicting or creating new ideas.

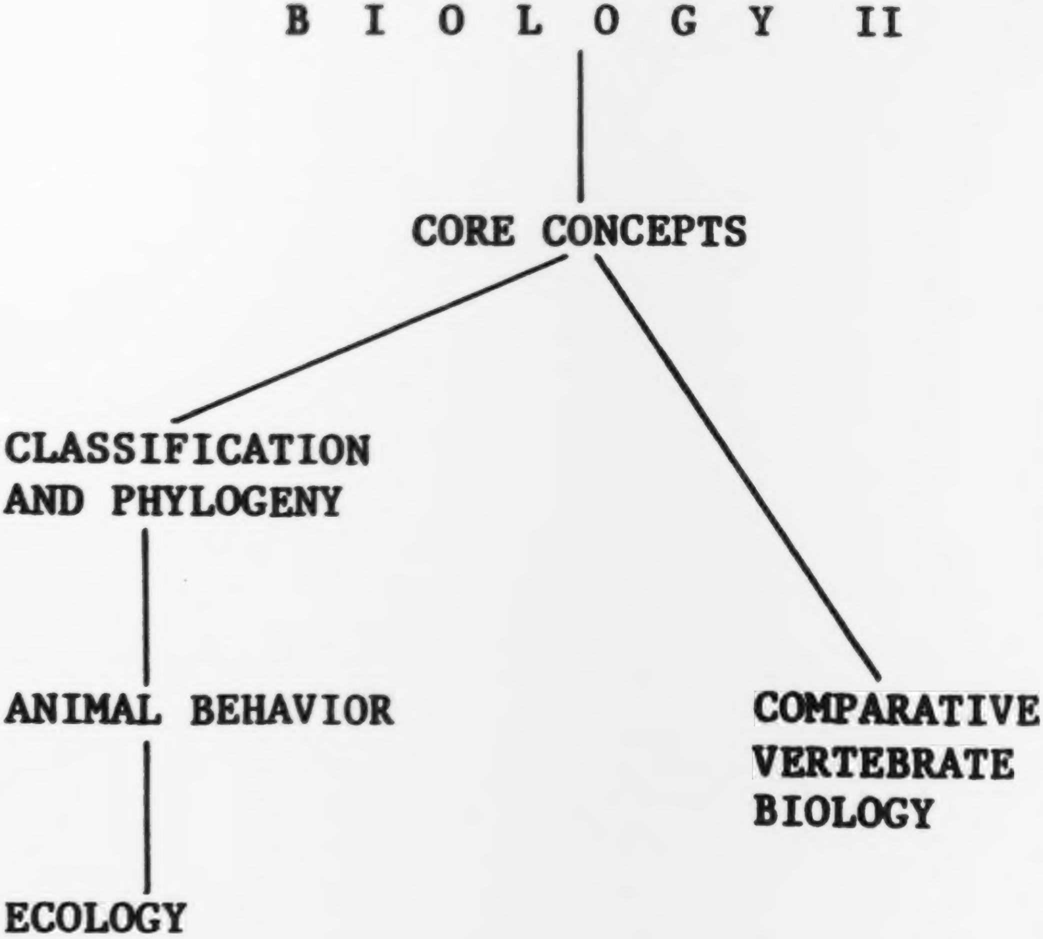
Science, Technology, and Society is a component of the science curriculum that addresses the relationship or interaction between science and technology, two unseparable areas and society. Science is often described as having no relationship with society; however, with emerging change brought on by the industrial revolution, science and technology have helped shape society. The effective domain is strongly linked to science through science, technology, society issues.

Biology II

Biology II is an advanced course designed for students who have been adequately prepared with Biology I, Physical Science, and Chemistry. Even though chemistry is not required as a prerequisite it is recommended that students enrolled in Biology II will have taken chemistry or will be concurrently enrolled in a course. This course is designed to address the need for more advanced courses. Biology II may be taught as an Advanced Replacement Course, providing guidelines from the College Board are followed. Biology II curriculum is based on a common core of material which all students taking the course will cover. This core is expected to be covered in no less than one semester. Following the completion of the core, one of two curricular formats may be selected by the teacher. One format, "general biology" continues a thorough study in the field of biology; a second format, comparative vertebrate anatomy and physiology, emphasizes vertebrate biology.

It is recommended that this course be based on the following allocated percentage of components.

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GOALS OF TEACHING BIOLOGY II

Science Literacy

The primary goal of science courses in grades K-12 is to promote science literacy. Before determining what should be taught, *science literacy* should be defined. Science literacy is the ability to perceive, comprehend, interpret, explain, and predict natural phenomena and to demonstrate such ability technologically. Many science educators recommend that science literacy should be not a separate entity but an integral component of the total curriculum. The perception, comprehension, interpretation, explanation, and prediction of a phenomenon should be fused into every area of the curriculum.

According to most science educators, a scientifically literate citizen should be:

1. aware that science is concerned with the empirical universe.
2. able to read accounts of developments by the scientific community.
3. aware that knowledge developed in the scientific community is probable rather than absolute.
4. aware of the difference between theoretical and empirical concepts and laws.
5. aware of how both empirical and theoretical concepts and laws come into being.
6. aware of the scientifically accepted regulatory principles.
7. aware that theoretical and empirical laws may be descriptive, comparative, or quantitative.
8. able to use theoretical laws in unifying empirical laws.
9. able to use empirical concepts and laws in a constant adjustment to the environment.
10. able to explain and to predict events in the environment in a rational manner.
11. able to translate experience of the natural world into knowledge.
12. able to communicate with other citizens about knowledge and ideas about natural objects and phenomena.
13. able to communicate with other citizens about the use or control of natural objects or forces.

Specific Goals

Achieving science literacy involves attitudes, process skills, concepts, and social aspects of science and technology. This literacy is linked to a global awareness that knowledge is increasing at a tremendous rate and that this rapid increase affects society in a great variety of ways. Based upon this belief, the following major goals of science are stated:

1. Fostering Positive Attitudes Toward Science and the Scientific Process

Developing a deep appreciation of the role of science and the scientific process will influence the way students think about the environment and about their effect on the environment.

2. Developing Process Skills

The development of process skills is an integral part of science activities for students. Students should be given opportunities to develop those intellectual processes of inquiry and thought by which scientific phenomena are explained, measured, predicted, organized, and communicated. These experiences will serve to reinforce scientific concepts.

Basic Scientific Process Skills used in solving problems and making decisions include observing, inferring, classifying, using numbers, measuring, using space-time relationships, communicating, predicting, and designing experiments. Integrated Process Skills include controlling variables, defining operationally, formulating hypotheses, interpreting data, and experimenting.

3. Acquiring Knowledge

Included in the basic science curriculum are those scientific concepts, principles, theories, and laws that will enable the students to understand and interpret natural phenomena. Applying scientific concepts, principles, theories, and laws requires the understanding of cause-effect relationships; energy-matter relationships; time-space relationships; revolutionary, evolutionary, or catastrophic change; interaction of variables; systems; symmetry; and equilibrium.

4. Recognizing the Interaction of Science, Technology, and Society

The students should (a) understand the interrelationships of science, technology, and social and economic development, (b) recognize both the limitations and the usefulness of science and technology in advancing human welfare, and (c) understand the concept of global ethics when new technologies are used. Science and technology are difficult to separate because scientists often develop new technology and new technology produces new avenues for scientists to obtain new knowledge. Changes in science and technology may not always improve society and may be the subject of moral, religious, or ethical questions. Such controversial issues cannot be solved in a science classroom but may be discussed.

PRIMARY PROCESS SKILLS

Within the framework of all science, nine basic process skills are stressed: (1) observing, (2) inferring, (3) classifying, (4) recognizing number relations, (5) measuring, (6) recognizing space-time relationships, (7) communicating, (8) predicting, and (9) decision making. There is a progressive intellectual development with each process. A brief description of each basic process follows.

OBSERVING

Observing is the use of one or more of the five senses to perceive properties of objects or events as they are. Statements about observations should be: (1) quantitative where possible, (2) descriptive regarding change(s) and rates of change(s), and (3) free of interpretations, assumptions, or inferences.

INFERRING

Inferring is making statements about objects or events based on observations which are not the result of direct perception. Inferences may or may not be accurate interpretations or explanations of observations. Inferences are based on: (1) observation, (2) reasoning, and (3) past experience of the observer. Inferences require evaluations and judgment. Inferences based on one set of observations may suggest further observation which in turn requires modification of original inferences. Inferences lead to predictions.

CLASSIFYING

Classifying is the grouping or ordering of phenomena according to an established scheme. Objects and events may be classified on the basis of observations. Classification schemes are based on observable similarities and differences in arbitrarily selected properties. Classification keys are used to place items within a scheme as well as to retrieve information from a scheme.

RECOGNIZING NUMBER RELATIONS

Finding qualitative relationships is not adequate when solving problems. Quantitative relationships among data with symbols assist in verifying relationships.

MEASURING

Measuring is to find out the extent, size, quantity, capacity, etc., of something, especially by comparison with a standard. Once the concept of measuring is introduced and mastered in kindergarten and the first grade, the metric and or SI system should be used exclusively.

RECOGNIZING SPACE/TIME

Recognizing space-time relationships is the process that develops skills in the description of spatial relationships and their changes with time. It includes the study of shapes, time, direction, spatial arrangement, symmetry, motion, and rate of change.

COMMUNICATING

Communicating is to pass information from one person to another. Communications may be oral, nonverbal (e.g., gestures), written, or pictorial (pictures, maps, charts, and graphs). Communications should be concise, accurate, clear, and precise descriptions of what is perceived.

PREDICTING

Predicting is forecasting what future observations might be; it is closely related to observing, inferring, and classifying. The reliability of predictions depends upon the accuracy of past and present observations and upon the nature of the event being predicted.

DECISION-MAKING SKILLS

Decision-making skills are based on evaluation and synthesis. Decision-making is one link from science to other areas of the curriculum. Value judgments generally should be based on accurate information obtained scientifically. Evaluation implies value judgment based on many factors. Within the framework of environmental science, many evaluations must be made. Decisions, especially those having social, political, or economic consequences, are seldom made with only scientific considerations.

INTEGRATED PROCESSES OF SCIENCE

As basic progressive, intellectual development proceeds in each process skill, the interrelated nature of the processes is manifested in the five integrated processes: (1) controlling variables, (2) defining operationally, (3) formulating hypotheses, (4) interpreting data, and (5) experimenting. A brief description of each integrated process follows.

CONTROLLING VARIABLES TO ANALYZE SYSTEMS AND FORMULATE MODELS

A variable is any factor in a situation that may change or vary. Investigators in science and other disciplines try to determine what variables influence the behavior of a system by manipulating one variable, called the manipulated (independent) variable, and measuring its effect on another variable, called the responding (dependent) variable. As this is done, all other variables are held constant. If there is a change in only one variable and an effect is produced on another variable, the investigator can conclude that the effect has been brought about by the changes in the manipulated variable. If more than one variable changes, there can be no certainty at all about which of the changing variables causes the effect on the responding variable. All students of science should understand the use of independent and dependent variables.

DEFINING OPERATIONALLY BY GATHERING AND PROCESSING INFORMATION

To define operationally is to choose a procedure for measuring a variable. In a scientific investigation, measurements of the variables are made; however, the investigator must decide how to measure each variable. An operational definition of a variable is a definition determined by the investigator for the purpose of measuring the variable during an investigation; thus, different operational definitions of the same variable may be used by different investigators.

FORMULATING AND USING DEDUCTIVE-NORMATIVE EXPLANATIONS

To formulate a hypothesis is to make a guess about the relationships between variables. A hypothesis may be stated before any sensible investigation or experiment is performed because the hypothesis provides guidance to an investigator about the data to collect. A hypothesis is an expression of what the investigator thinks will be the effect of the manipulated variable on the responding variable. A workable hypothesis is stated in such a way that, upon testing, its credibility can be established.

EXPERIMENTING USING INTEGRATED PROCESS SKILLS

Experimenting is the process of designing a procedure that incorporates both the basic and the integrated process skills. An experiment may begin as a question for the purpose of testing a hypothesis. The basic components of experimenting are:

1. Constructing a hypothesis based on a set of data collected by the investigator from observations and inferences.
2. Testing the hypothesis. The variables must be identified and controlled as much as possible. Data must be collected and recorded.
3. Describing or interpreting how the data support or do not support the hypothesis, i.e., deciding whether the hypothesis is to be accepted, modified, or rejected.
4. Constructing a revised hypothesis if the data do not support the original hypothesis.

INTERPRETING AND COMMUNICATING SCIENTIFIC INFORMATION

The process of interpreting data may include many of the following behaviors: (1) recording data in a table, (2) constructing bar or line graphs, (3) making and interpreting frequency distributions, (4) determining the median, mode, and range of a set of data, (5) using slope or analytical equations to interpret graphs, and (6) constructing number sentences describing relationships between two variables. Interpreting data requires going beyond the use of the skills of tabulating, charting, and graphing to ask questions about the data which lead to the construction of inferences and hypotheses. Interpretations are always subject to revision in the light of new or more refined data.

CONTENT OUTLINE

I. History of Studying Biology
II. Process of Biological Investigation
  A. Introduction of scientific method
    1. Theories, hypotheses, and laws
    2. Methods of formulating hypotheses
    3. Experimental design
    4. Variables identification
    5. Data collecting methods
    6. Control of data
    7. Data interpretation
    8. Synthesizing new hypotheses
    9. Measuring for laboratory investigation
    10. Revision of hypotheses
  B. Introduction of statistics
    1. Value of statistics
    2. Discrete and continuous variables
    3. Sampling
    4. Using statistics to support and experimental design
    5. Arithmetic mean
    6. Variance
    7. Normal distribution
    8. Standard deviation
    9. Null hypothesis
    10. T-test
    11. Chi-square
    12. Test of significance
III. Chemistry
  A. Chemical bonds
  B. Structure of matter
    1. Water, H_2O
    2. Ammonia, NH_3
    3. Carbon dioxide, CO_2
    4. Methane, CH_4
    5. Oxygen, O_2
    6. Sulfide, $S-S$
  C. Water and the environment
  D. Acids and bases

- E. Organic chemistry
    1. Structure of carbon
    2. sp^3 orbital
    3. Functional groups
- F. Biochemistry
    1. Essential metabolic compounds
    2. Energy molecules
    3. Carbohydrates
    4. Lipids and phospholipids
    5. Enzymes
    6. Proteins
    7. Porphyrins
    8. Nucleic acids

IV. Cellular Biology

- A. Structure and Function
    1. Prokaryotic and eukaryotic cells
    2. Plant cells and animal cells
    3. Membrane
    4. Cell organelles and functions
    5. Cell structure and mobility
- B. Cell Cycle
- C. Cell Differentiation and Tissues
    1. Plants
    2. Animals
- D. Cellular transport
    1. Osmosis
    2. Active transport
- E. Metabolism
    1. Evolution of metabolism
    2. Biochemical pathways
- F. Photosynthesis
    1. Dark phase
    2. Light phase
    3. Chlorophyll
    4. Respiration
    5. Factors affecting photosynthesis

- G. Sex and cellular reproduction
  1. Mitosis
  2. Meiosis
  3. Oögenesis
  4. Spermatogenesis
  5. Sexual reproduction
  6. Reproductive success
  7. Reproductive strategies
- H. Immunology
  1. Nonspecific and specific defense mechanisms
  2. Importance and Development in invertebrates and vertebrates
  3. Types of immunity
  4. Role of defense systems
  5. Role of cell
  6. Plasma proteins
  7. Lymphatic system
  8. Antigen-antibody reactions
  9. Allergic reactions
  10. Theraputic alternatives
  11. Transplantation, tolerance, autoimmunity

V. Genetics and Heredity

- A. Laws of Inheritance
  1. Mendelian genetics
  2. Laws of probability
  3. Sex linked traits
  4. Multiple alleles
  5. Gene interaction
  6. Lethal genes
  7. Chromosomal aberrations
- B. Gene Function
  1. Sequence of DNA replication
  2. Components of a gene
  3. Genetic code
  4. Mutations
  5. Cancer
  6. Autosomal linkage and crossing over
  7. Recombinant DNA

        8. DNA cloning
        9. Hybridization
        10. DNA sequencing
        11. RNA and DNA viruses
        12. Gene technology
        13. Gene mapping

VI. Evolution
    A. Early ideas
        1. Creation
        2. Lamarckism
        3. Uniformitarianism
    B. Development of Evolutionary Theory
        1. Darwin's Theory of Natural Selection
        2. Issues in evolution
        3. Adaptation
    C. Evidence for Evolution
        1. Fossils and the formation of fossils
        2. Geological time
        3. Dating fossils and geological materials
        4. Classification and homology
        5. Biochemical homology
    D. Microevolution
        1. Hardy-Weinberg principle
        2. Gene frequencies
        3. Genetic variation within species
        4. Genetic drift
        5. Adaptive radiation
        6. Sympatric speciation
        7. Convergent and divergent evolution

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END OF CORE

CLASSIFICATION AND PHYLOGENY

VII. Taxonomy and systematics
  A. History
    1. Polynomial system
    2. Binomial system
    3. Species
  B. Dichotomous key
    1. Development
    2. Use
  C. Levels of classification
VIII. Microbiology
  A. Monera
    1. Bacteria cell structure
    2. Bacteria cell division
    3. Metabolism
    4. Groups of bacteria
    5. Ecological relationships to man and other organisms
  B. Protista
    1. Cell structure
    2. Mobility
    3. Reproduction
    4. Groups of Protista
    5. Ecological relationships to man and other organisms
  C. Fungi
    1. Cell structure
    2. Reproduction
    3. Classification
    4. Ecological relationships to man and other organisms
  D. Viruses
    1. Special characteristics
    2. Ecological relationship to man

VERTEBRATE ANATOMY AND PHYSIOLOGY

VII. Organization of the vertebrate body
  A. Fields of study relating to vertebrate study
  B. Levels of organization of animals
    1. Body cavities of vertebrates
    2. Nine body systems of vertebrates
  C. Comparative cellular organization and development (Embryology)
    1. Epithelium
    2. Connective tissue
    3. Muscle
    4. Nerve tissue
VIII. Supporting framework and movement
  A. Skeleton development
    1. Function
    2. Structure of long bones
    3. Axial and appendicular skeleton
  B. Physiology
    1. Joints and movement
    2. Formation of bone
IX. Muscle tissues
  A. Anatomy and histology
  B. Physiology
    1. Mechanism of contraction
    2. Source of energy
    3. Properties of contraction
  C. Skeletal muscles
    1. Origin and insertion
    2. Group action
    3. Axial skeleton muscles
X. Coordination and control of the body
  A. Nervous tissue
    1. Structure

IX. Plants
- A. Plant groups
  - 1. Nonvascular
  - 2. Vascular
- B. Taxonomy of plants
  - 1. Bryophytes
  - 2. Gymnosperms
  - 3. Angiosperms
- C. Life cycles of nonvascular plants
  - 1. Liverworts
  - 2. Mosses
  - 3. Ferns
- D. Alternation of generations
- E. Anatomy and Physiology of vascular plants
  - 1. Leaves
  - 2. Stems
  - 3. Roots
  - 4. Adaptations
- F. Sexual reproduction
  - 1. Flower structure and diversity
  - 2. Pollination
  - 3. Seed development
  - 4. Seed diversity
  - 5. Dispersal
- G. Asexual reproduction
  - 1. Vegetative propagation
  - 2. Cloning
- H. Responses
  - 1. Taxis
  - 2. Tropisms
- I. Plant hormones
  - 1. Growth regulation
  - 2. Response to stimuli
- J. Photoperiodicity

X. Animal diversity
- A. Introduction
  - 1. Radially symetrical animals
    - a. Cnidaria
  - 2. Neuron physiology
  - 3. Axial skeleton muscles
- B. Nervous system
  - 1. Central nervous system
  - 2. Peripheral nervous system
  - 3. Physiology
  - 4. Autonomic nervous system
- C. Vision
  - 1. Anatomy and histology
  - 2. Accessory organs
  - 3. Physiology of sight
  - 4. Chemistry of vision
  - 5. Disorders
- D. Hearing
  - 1. Comparative Anatomy and Histology
  - 2. Physiology

XI. Comparative Digestive System of Vertebrates
- A. Nutrition
  - 1. Nutrients
  - 2. Enzyme activity
  - 3. Nutrition and health
- B. Mouth, pharynx, esophagus
  - 1. Anatomy
  - 2. Physiology and histology
  - 3. Disorders
- C. Stomach
  - 1. Structure
  - 2. Physiology
  - 3. Disorders
- D. Intestines
  - 1. Anatomy and histology
  - 2. Function
  - 3. Large intestines
  - 4. Liver and bile secretion
  - 5. Pancreatic functions

XII. Comparative respiratory systems of vertebrates
- A. Respiratory organs
  - 1. Anatomy and histology

- b. Ctenophora
- 2. Bilaterally symetrical animals
  - a. Acoelomates
  - b. Pseudocoelomates
  - c. Coelomates
    - 1) Mollusca
    - 2) Annelida
    - 3) Arthropoda
    - 4) Echimodermata
    - 5) Hemichodata
    - 6) Chordata
- B. Invertebrates
- C. Vertebrate diversity
- D. Vertebrate homeostasis

XI. Comparative Physiology
- 1. Transport systems
- 2. Muscle system
- 3. Nervous system
- 4. Digestive system
- 5. Endocrine system
- 6. Reproductive system

XII. Comparative Embryology

XIII. Animal Behavior

XIV. Ecology
- A. Definition of environment
- B. Ecological organization
- C. Energy pathways
- D. Biogeochemical
- E. Communities
- F. Population dynamics
- G. Human ecology
  - 1. Human cultural evolution
  - 2. Human population
  - 3. Nonrenewable/renewable resources
- H. Pollution
  - 1. Natural
  - 2. Man-made

- 2. Physiology
- 3. Disorders
- B. Breathing mechanics
  - 1. Gas exchange
    - a. Properties of gas laws
    - b. Diffusion of gases
  - 2. Respiration
  - 3. Disorders
- C. Respiratory physiology
  - 1. Gas exchange and transport
  - 2. Pathology of the respiratory system

XIII. Transport System
- A. Blood
  - 1. Formed elements
  - 2. Plasma
  - 3. Hematopoiesis
  - 4. Physiology
- B. Heart
  - 1. Anatomy
  - 2. Coronary circulation
  - 3. Cardiac cycle
  - 4. Control of heart
  - 5. Rate of heart beat
- C. Vascular system
  - 1. Anatomy and histology
  - 2. Physiology of vessels
- D. Lymphatic system
  - 1. Structure and organs

XIV. Metabolism and Regulation
- A. Skin
  - 1. Histology
  - 2. Physiology
- B. Body temperature
  - 1. Heat
  - 2. Maintaining body temperature
  - 3. Disorders

- C. Kidney
  - 1. Anatomy
  - 2. Physiology
  - 3. Disorders
- XV. Endocrine System
  - A. Endocrine glands and functions of hormones
    - 1. Histology of glands
    - 2. Physiology
    - 3. Disorders of Endocrine System
- XVI. Comparative Reproduction of Vertebrates
  - A. Reproductive organs
    - 1. Female system
    - 2. Male system
  - B. Physiology
    - 1. Testicular function
    - 2. Ovarian function
    - 3. Embryological formation
    - 4. Embryological development

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
* Review from Biology I		
** Review from Biology I, but more in depth study in Biology II		
I. HISTORY OF BIOLOGY		
**1. The student will briefly trace the development of the biological sciences from ancient cultures to the present.	History of biology	1. Library research on assigned topics dealing with ancient culture and famous historical biologists. 2. Films, filmstrips, videos related to the history of biology.
**2. The student will state the names of ten famous biologists and their contributions to the growth of biology. These may include Hippocrates, Aristotle, Pliny, Linnaeus, Darwin, Wallace, Mendel, and Pasteur.	History of biology	1. Set up lab demonstrations that illustrate Pasteur's and Redi's refutation of spontaneous generation. 2. Identify significant contributions to the field of biology beginning with the Hellenistic-Roman Period. Some of the persons would include Hippocrates, Empedocles, Aristotle, Pliny, and Galen. Arabic contributions were by Rhazes, Ibn-Sina. A Chinese biologist was Chi Han. Europeans include Roger Bacon, Leonardo da Vinci, Gesner, Vesalius, Harvey, Leeuwenhoek, Van Helmont, Spallanzani, Linnaeus, Cuvier, Lamarck, Darwin, Wallace, Redi, Pasteur, Agassiz, Mendel, and Huxley. Examine contemporary biologists and their contributions. Example--Watson and Crick, Odum, Salk, others.
**3. The student will be able to discuss some mile-stones in biology over the past 50-100 years.	History of biology	1. Identify periods of history in which major breakthroughs were made in science.

	OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**4.	The student will be able to discuss current events in the area of biology.	History of biology	1. Invite guest speakers from colleges, universities, or industry to speak on current research topics.
II.	PROCESSES OF BIOLOGICAL INVESTIGATION		
A.	INTRODUCTION OF SCIENTIFIC METHOD		
*5.	The student will explain the differences between theories, hypotheses, and laws.	Scientific method	1. Review a Biology I activity.
*6.	The student will form hypotheses based on observations of biological phenomena.	Hypothesis	1. Use the discussion on the Atolls and how they formed.
**7.	The student will design experiments to test hypotheses.	Experimental design	1. Have students fabricate hypothetical experiments to test hypotheses.
**8.	The student will recognize the variables involved in biological investigations and design experiments where the number of variables is controlled.	Manipulate variables	1. Review a Biology I activity.
**9.	The student will describe different methods of collecting data in an investigation.	Data collection	1. Review a Biology I activity.
10.	The student will recognize that all variables may not be controlled in the design of an experiment.	Control	1. Review a Biology I activity.

	OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
*11.	The student will interpret data in light of prestated hypotheses.	Data interpretation	1. Review a Biology I activity.
*12.	The student will recognize data that supports or rejects stated hypotheses.	Data support of hypothesis	1. Review a Biology I activity.
*13.	The student will recognize that investigations may create new questions.	Synthesize new hypothesis	1. Review a Biology I activity.
B.	INTRODUCTION OF STATISTICS		
14.	The student will identify descriptive statistics that are used to evaluate numerical data.	Introduction to statistics	1. Review a Biology I activity. 2. Encourage students to develop science projects using the above processes.
15.	The student will demonstrate that statistics are not used to prove things but to support probabilities.	Support value of statistics to probabilities	1. Have students examine newspaper polls or magazine polls. Demonstrate how such information can be skewed.
16.	The student will identify the difference between discrete and continuous variables.	Discrete and continuous variables	1. Provide students with a table of data and have them construct an appropriate graph. 2. Have students determine the differences between different types of data.
17.	The student will identify the difference between random and biased samples.	Random and biased samples	1. From sets of data have students determine the mean, median, and mode.
18.	The student will design and carry out an experiment that requires the selection of a random sample.	Random sampling	1. Students collect data from available sources, e.g., media, student surveys, public records, and from descriptive statistics.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
19. The student will recognize when samples are biased.	Recognition of biased samples	1. Students view television, read newspapers and report on examples of biased or random sampling.
*20. The student will be able to demonstrate the ability to find the arithmetic mean, given a set of data.	Mean	1. Introduce data collecting by using class mean and school mean.
21. The student will be able to compute the variance.	Variance	1. Have students determine the weight in grams of 10 marbles of similar size and 10 pebbles of various sizes. From the results, students calculate and compare the variance and standard deviation of each group. 2. Introduce concepts relating to standardized tests (NRT) and discuss percentiles.
22. The student will be able to demonstrate the ability to find the standard deviation and to state what is meant by "normal" distributions.	Normal distribution	1. Have students compute the variance and standard deviation of a set of test data.
23. The student will use standard deviation in determining how much a set of data varies from the mean.	Standard deviation	1. Have students develop a project that requires the collection of two sets of data. Use a T-test to determine if the null hypothesis is correct.
24. The student will design and carry out an experiment which makes use of variance and standard deviation.	Use of statistics in experiments	1. Have students design an experiment that uses basic statistical concepts.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
25. The student will be able to define and state a null hypothesis.	Null hypothesis	1. Have students develop a procedure for sampling students in their school for opinions or some factor which can be measured. Example might be student height. From the data compute the mean, median, mode, determine variance, and standard deviation.
26. The student will solve problems using the t-test and the chi-square test.	The t-test and chi-square	1. Have students work problems using the t-test and chi-square. 2. Have students develop a table like the one listed below and ask the students to develop hypotheses and test them with a t-test.

TWO-WAY FREQUENCY TABLE

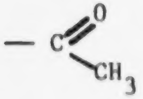
	EYE COLOR			
SEX	BROWN	BLUE	OTHER	TOTALS
MALE	450	225	50	775
FEMALE	475	255	60	790
TOTALS	925	470	110	1565

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
27. The student will design and carry out an experiment which involves a test of significance.	Test of significance	1. Students are given the results of monohybrid or dihybrid crosses. Use the chi-square test to determine if predicted data is significantly different from actual data. 2. Have students measure the height of two sets of plants grown in different environments (environments may be different light intensities, temperatures, or availability of water). Use the t-test to determine if a significant difference exists between the two sets of plants.
III. CHEMISTRY		
A. CHEMICAL BONDS		
*28. The student will be able to describe ionic and covalent bonding.	Chemical bonding	1. Review chemistry labs that emphasize chemical bonds.
B. STRUCTURE OF MATTER		
*29. The student will describe the unique structure of specific elements and compounds, such as: H_2O - water CO_2 - carbon dioxide CH_4 - methane NH_3 - ammonia O_2 - oxygen S-S - sulfide	Atomic structure	1. Have students construct models of the specific elements and compounds using either packaged models or styrofoam balls and toothpicks. 2. Have students examine compounds found in living systems and identify specific compounds.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
C. WATER AND THE ENVIRONMENT		
**30. The student will be able to describe the characteristics of water and its relationship to the environment.	Atomic structure of water	1. Review physical chemistry of water. 2. Identify sources of water and limits of fresh water. 3. Have students identify environmental factors affecting water.

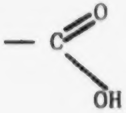
OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
D. ACIDS AND BASES		
**31. The student will be able to demonstrate the ability to determine the pH in living systems and their environments.	Acids and bases	1. Students will prepare slides made of various color flower petals. Add acid or base to petals and check for color change. 2. Students will collect either soil or water samples or both and check for pH level. 3. Discuss environmental problems associated with unnatural shifts in pH.
E. ORGANIC COMPOUNDS		
*32. The student will recognize the basic chemicals of life such as CO_2, NH_3, and CH_4.	Structure of carbon	1. Discuss Miller's experiment and identify problems associated with the experiment. Many dispute that the amino acids formed from his experiment are not naturally found. Have students investigate. 2. Discuss findings from NASA research regarding atmosphere on planets or moons in our solar system.
*33. The student will describe the uniqueness of the Carbon atom and the sp^3 orbital essential to all organisms.	sp^3 orbital	1. Construct models with styrofoam balls and toothpicks or balloons. Use transparencies. 2. Have students conduct a laboratory activity to determine how to classify organic and inorganic compounds by investigating its combustibility. Have students test samples of sugar (sucrose) sodium chloride, paradichlorobenzene, calcium carbonate, mineral oil, napthalene, paraffin, rubber, wood, graphite, soap, bacon, aspirin, Ammonium dichromate. Place

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		each sample in a can lid from home. (Dent lid with a ballpeen hammer.) Direct a flame on each sample and record results.
*34. The student will recognize the basic functional groups of organic compounds and will be able to draw and define each. These include	Functional groups	1. Have students examine written compounds and determine if any of the functional groups are present.



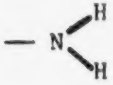
Acetyl

— OH Hydroxyl

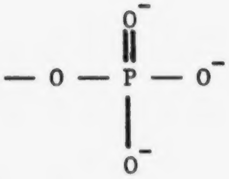


Carboxyl

— SH Sulfhydryl



Amino



$$-\mathrm{O}-\underset{\mathrm{O}^-}{\underset{|}{\overset{\mathrm{O}^-}{\overset{\|}{\mathrm{P}}}}}-\mathrm{O}^-$$

Phosphate

	OBJECTIVE	CONCEPT		SUGGESTED ACTIVITIES
F.	BIOCHEMISTRY			
*35.	The student will recognize the four major types of compounds involved in metabolic reaction of all animals. These include H_2O, CO_2, NH_3, and $C_6H_{12}O_6$.	Essential metabolic compounds	1.	Have students examine a Krebs cycle chart or one containing metabolic pathways.
**36.	The student will distinguish the various types of energy-storing molecules, e.g.., sugars, starches, cellulose, fats, and chitin.	Energy molecules	1.	Have students conduct an experiment to show that small differences in structure can affect a material. Use sugar from glucose, sucrose, galactose, maltose, fructose, and lactose. Develop a chart and list each sugar type and structural formula. Determine each sweetness level. Determine which types of sugars are more sweet than others. (See Molecules of Living Systems, 1975. Harper & Row, Publishers: New York.)
			2.	Have students examine the structure of cellulose and chitin and starches and determine why some may be digested and others may not.
**37.	The student will recognize various unique polysaccharides such as cellulose, glycogen, and chitin and identify their differences.	Carbohydrates	1.	Have students chew on sugarcane or celery (cellulose), observe crayfish or insect exoskeletons (chitin) and review the function of the liver in storing glycogen.
*38.	The student will recognize the various kinds of fat (lipid) molecules and will be able to distinguish saturates,	Lipids	1.	Students will bring in common household examples of each.

	OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
	unsaturates, and polysaturate molecules.		2. Have students conduct physical separation of each lipid. 3. Examine slides of fat cells and compare with other cells.
**39.	The student will recognize membrane structure and how phospholipids function.	Membrane structure	1. Examine electron micrographs and diagrams showing membrane structure.
*40.	The student will define enzymes as biological catalysts.	Enzymes	1. Salivary Amylase - Campbell's Lab Manual, Goodenough, 1987.
*41.	The student will recognize that proteins are made up of peptides and be able to define their major building blocks as amino acids.	Proteins	1. Have students conduct a digestion laboratory demonstrating enzymatic hemolysis of a protein. Use gelatin and a meat tenderizer. Ask students to determine how the tenderizer digests the gelatin. 2. Obtain information regarding health foods and extra protein meals.
42.	The student will distinguish between a peptide bond and an ester bond.	Peptides	1. Have students conduct experiments with meat tenderizers and determine how they work.
43.	The student will identify porphyrin structures such as hemoglobin and chlorophyll.	Porphyrin structures	1. Refer to Advanced Placement Laboratory II on plant pigments in APPENDIX.

	OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**44.	The student will identify basic structures of nucleic acids.	Nucleic acids	1. Compare nucleic acids and describe how their structure was identified. 2. Refer to the book "Double Helix" by Watson and Crick. 3. Use A-V material to present background on nucleic acids.
IV.	CELLS		
A.	STRUCTURE AND FUNCTION		
**45.	The student will compare and contrast prokaryotic and eukaryotic cells.	Prokaryotic and eukaryotic cells	1. Examine various prepared or fresh specimens of plant and animal cells. 2. Examine ultra electron micrographs of cell walls and membranes.
*46.	The student will compare and contrast plant and animal cells.	Plant and animal cells	1. Have student examine tissues from both plants and animals with stereo and compound microscopes.
**47.	The student will identify the structure and list functions of the cell membrane including exocytosis and endocytosis.	Cell membrane	1. Changes in egg cells, red onion, elodea, spirogyra, paramecia, ameba, caused by osmosis. 2. Film loop or film showing contractile vacuole motion 3. Study hemolysis of red blood cells and other tissues.
**48.	The student will list the structure and function of organelles, the subcellular components of mobility, and the cytoskeleton.	Cell structure and mobility	1. Use electron micrographs of subcellular components. Followed by identification of organelles from diagrams in available textbooks.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
B. CELL CYCLE		2. Report on literature regarding the function of each organelle.
**49. The student will identify and compare the various stages of the cell cycle: mitosis, cytokinesis, interphase.	Cell cycle	1. Examine onion root tips and white fish embryo, either through commercially prepared slides or slides made from fresh onion root tips.
C. CELL DIFFERENTIATION AND TISSUES		2. Use audio visuals to demonstrate cycle. Use 35mm slides or BSCS 8mm film loops.
*50. The student will be able to microscopically identify the different types of plant and animal tissues.	Plant and animal tissues	1. Examine slides of tissues from plants and animals. Have students compare structures with stereoscopes. 2. Prepare slides of various plant tissues. Stain with various chemicals to show absorption of organelles.
*51. The student will be able to give the locations and functions of the different types of tissues.	Function of tissue	1. Examine slides of tissues and identify where each are found with in animals and plants.
52. The student will define and differentiate between the various kinds of tissues, e.g., epithelial, muscular, connective, and nervous and how they form organs.	Differentiate basic tissues	1. Examine tissues slides from a pathology laboratory. 2. Obtain tissue slides from a histology or cytotechnology class and compare. 3. Use a microtome and prepare slides

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		from freshly prepared tissues.
		4. Refer to histology textbooks to examine photographs of various tissues.
**53. The student will explain the characteristics of the three basic epithelial tissues and describe where they are found.	Epithelial tissues	1. Examine the inter-lining of the stomach and draw a cross-section and study different tissue types.
**54. The student will identify the three types of muscular tissues (striated, smooth, and cardiac) and describe the general characteristics of each.	Muscular tissues	1. Have students examine gross anatomy of organs and then follow up with microscopic slides.
55. The student will list the major parts of a skeletal muscle both at the macroscopic and microscopic levels.	Ultra structure of skeleton muscle	1. Use video tapes to show how actin and myosin fibers contract.
D. CELLULAR TRANSPORT		
*56. The student will describe the concept of osmosis.	Osmosis	1. Students will prepare slides made from elodea, red onion skin, or spirogyra in fresh water; remove water by using absorbent paper and add salt water solution to slide; remove with absorbent paper and add distilled water to slide.
**57. The student will describe the process of active transport.	Active transport	1. Describe to the students an experiment using an inverted intestine and sugar solution.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
E. METABOLISM		
58. The student will describe the evolution of metabolism at the cellular level, e.g., fermentations, degradation of organic molecules, nitrogen fixation, and anaerobic photosynthesis.	Metabolism and its development	1. Investigate and discuss the origin of blue-green bacteria, anaerobic, and aerobic bacteria. 2. Examine blue-green algae under the microscope.
59. The student will be able to describe the various stages of glycolysis and cellular respiration.	Glycolysis, and Krebs, or citric acid	1. Laboratory II - AP Biology Laboratory with plant pigments (in Appendix) A. cholorophyll - chromatography B. stomate activity (CO_2 amounts) 2. Use a cross section of leaf. 3. Use filmstrips on photosynthesis and cellular respiration. 4. Experiment on factors that affect enzymes (pH, temp. concentration).
F. PHOTOSYNTHESIS		
**60. The student will be able to identify the various stages of dark and light reactions of photosynthesis.	Photosynthesis	1. Use various plants to demonstrate both phases of photosynthesis. 2. Have students read and discuss Van Helmont's experiment and Joseph Priestly's findings. Ask students why Priestly's experiments could not be repeated.
**61. The student will describe how chlorophyll and other pigments are used by plants to absorb various wave lengths of light.	Chlorophyll	1. Separate the chlorophyl pigment of of spinach using acetone and ether. Use paper chromotography (refer to BSCS green version activity 12.2).

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**62. The student will demonstrate an understanding of the biochemistry of photosynthesis. This would include the role of oxygen, carbon dioxide, water, and the transformation of ATP and ADP.	Biochemistry of photosynthesis	1. Have students develop a flow chart of the complete process of photosysthesis.
*63. The student will identify ways in which pollution affects photosynthesis.	Pollution system in plants	1. Conduct a lab on plants. Cover some plants with a coating of opaque, and translucent material. Maintain a control. (Ingehouse's experiment).
G. SEX AND CELLULAR REPRODUCTION		
**64. The student will be able to differentiate between mitosis and meiosis.	Mitosis and meiosis	1. Human ovary and testes slide 2. Films, filmloops, filmstrips 3. Use a lily anther grain, squash technique and stain with aceto-orcein. Describe meiotic stages. Reference 1987, Cambell's Lab Manual.
**65. The student will be able to describe the stages of oögenesis and spermatogenesis.	Oögenesis and spermatogenesis	1. Have students view films or 35mm slides that show the process of gametogenesis.
**66. The student will be able to describe the advantages and disadvantages of sexual reproduction.	Sexual reproduction	1. Discuss the evolutionary development of sexual reproductions. Cite examples unique to the animal or plant kingdoms.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**67. The student will identify factors that affect an organism reproductive success. Such factors would include age of reproduction, litter size, number of litters per lifetime, interval of birth and reproductive cost.	Reproductive success	1. Have students examine computer programs that present population growth based on fecundity.
**68. The student will describe reproductive strategies.	Reproductive strategies	1. Discuss with students the reproductive strategies, or r and K strategies.
H. IMMUNOLOGY		
69. The student will be able to differentiate between nonspecific defense mechanisms and specific defense mechanisms in the immune system.	Immune system, nonspecific and specific system	1. Have the students compare and contrast the function of white blood cells in invertebrates and vertebrates. 2. Have the students discuss the differences in the immune systems found in vertebrates.
70. The student will be able to explain the importance of the development of an immune system in the vertebrates.	Vertebrate immunity	1. Use videos, films, transparencies or other visual aids. Refer to discussions associated with autoimmune deficiency syndrome (AIDS).
**71. The student will be able to identify the types of immunity.	Types of immunity	1. Give the students simulated exercises under which immunity develops and have them predict the type of immunity found.
72. The student will be able to identify the role of antibiotics, interferons, chemical inhibitors in plants, and the complement system.	Role of defense systems	1. Have the students prepare a list of common antibiotics used by their family and why they were prescribed. Tell how they affect the immune system.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
73. The student will be able to explain the role of the cells involved as specific defense mechanisms.	Role of cell	1. Invite guest speakers. 2. Use audiovisual materials. 3. Have the students make diagrams of the origin, storage, and destinations of each type of immune cell.
74. The students will be able to explain the role of plasma proteins.	Plasma proteins	1. Examine tubes of blood and have students note the difference between plasma and serum. Discuss the composition.
**75. The students will be able to explain why the lymphatic system is the center of immunity.	Lymphatic system	1. Give students hypothetical situations in which gamma globulins, vaccines, or other serums would be used.
**76. The student will be able to explain the immune response in terms of antigen-antibody reactions.	Antigen-antibody reactions	1. Have the students correlate all of the factors that are produced, relative to immunity, by the lymphatic system.
77. The student will be able to explain the body's allergic response to environmental factors.	Allergic reactions	1. Have the students discuss symptoms where there is an immune response taking place.
78. The student will be able to describe the therapeutic alternatives utilized to supplement a weakened immune system.	Therapeutic alternatives	1. Survey student as to which are allergic to common items. 2. Conduct library research on topics such as cancer, AIDS, or autoimmunity.

	OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
79.	The student will be able to relate transplatation, tolerance, and autoimmunity to the immune system.	Transplants, tolerance, autoimmunity	1. Examine current events and research topics such as transplantation and discuss problems associated with such procedures. 2. Discuss ethical issues relating to transplants and sources of transplant materials.
V.	GENETICS AND HEREDITY		
A.	LAWS OF INHERITANCE		
*80.	The student will explain the significance of Mendel's laws of heredity.	Mendelian genetics	1. Have students trace agricultural changes and focus on when and why changes occurred.
*81.	The student will explain the laws of probability.	Laws of probability	1. Conduct coin probability experiments. 2. Conduct fruit fly experiments. 3. Have students expand a binomial on a calculator.
**82.	The student will list and define several examples of inheritance patterns, e.g., sex-linked, sex-influenced, sex-limited.	Sex-linked traits	1. Work genetics problems using Punnett Squares. 2. Have students develop pedigree charts for animals or people who have known diseases. 3. Study established pedigree charts.
*83.	The student will be able to explain the terms chromosome, gene, allele, heterozygous, and homozygous.	Structures of genetics	1. Explore new ideas about alleles and chromosomes.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**84. The student will explain the results of gene interactions.	Gene interaction	1. Refer to lab "Genetic Segregation and Crossing Over" by Kent, Goodenough, 1987.
**85. The student will relate gene action to the cause of several human genetic defects, e.g., PKU, Down's Syndrome, Sickle-Cell Anemia, Cystic Fibrosis, Tay-Sachs.	Lethal genes	1. Guest speakers - Genetic counselors 2. Have students report on various types of conditions or disorders and present to the class.
B. GENE FUNCTION		
**86. The student will describe the steps of DNA replication and its involvement in translation and transcription.	DNA replication	1. Films, film loops, filmstrips, videos.
*87. The student will list causes of mutations.	Mutations	1. Use irradiated seeds to determine mutagenic effects. 2. Have students conduct library research regarding mutations. 3. Research information on cancer.
88. The student will be able to explain recombinant DNA, DNA cloning, hybridization, and DNA sequencing.	DNA in research	1. Films, videos. 2. Have students conduct library research.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
89. The student will be able to explain the following terms associated with gene technology: Split genes (introns-exons) Oncogene activity Gene mapping from cross-over data RNA processing Continuous-discontinuous DNA synthesis Karyotyping Chromosome-gene anomalies Point mutations Retroviruses Plasmids Tests for Genetic Anomalies 1. Alpha-fetoprotein test 2. Amniocentesis 3. Ultrasonography 4. Chorion biopsy	Gene technology	1. Have students research each topic and how each may affect them. 2. Invite guest speakers who can speak from experience or research. 3. Invite a gynocologist to speak. 4. Visit a laboratory that uses amniocentesis or ultrasonography. 5. Obtain films or video tapes that show ultrasonography. 6. Examine prepared karyotype slides and examine for abnormal conditions. 7. Prepare giant salivary gland chromosomes from fruit flies (*Drosophila melanogaster*).
VI. EVOLUTION		
A. EARLY IDEAS		
90. The student will state various theories concerning the origin of life.	Origin of life theories	1. Have student conduct library research and report to class. 2. Discuss with students the various views on where life came from. 3. Have students discuss differences between biological evolution and cosmology.
B. DEVELOPMENT OF EVOLUTIONARY THEORY		
91. The students will describe the development of evolutionary theory, its strengths and weaknesses in relation to biology.	Development of evolutionary theory	1. Discuss how Darwin and Wallace developed their ideas. 2. Discuss answers provided by evolutionary theory and direct relationship to the overall support of systematics.

	OBJECTIVE	CONCEPT		SUGGESTED ACTIVITIES
C.	EVIDENCE OF EVOLUTION			
**92.	The student will explain how natural selection affects evolution.	Natural selection	1.	Conduct a laboratory to introduce comparative anatomy as an explanation for development of evolution theories.
			2.	Conduct a laboratory on embryology to show similarities.
**93.	The student will list evidence supporting evolution. This evidence should include fossils and the formation of fossils, geological time, dating fossils, classification and homology and biochemical homology.	Evidence for evolution	1.	View films, T.V. programs (Nova) on Planet Earth.
			2.	Ask students to bring in fossils.
			3.	Conduct a field trip to an area rich in fossils.
			4.	Contact geologists or someone who has access to core samples.
			5.	Have the students develop a timeline to show the vastness of geologic time.
D.	MICROEVOLUTION			
**94.	The student will explain the significance of the Hardy-Weinberg principle in genetics.	Hardy-Weinberg principle	1.	Have students devise a chart of human genetic traits. Survey other classes to gather data. Determine frequency, determine statistics, and compare normal distribution.
95.	The student will describe factors influencing gene frequencies.	Gene frequencies	1.	Have students examine gene frequencies of various animals.
			2.	Examine the distribution of ABO blood types throughout the world.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
96. The student will describe the different patterns of evolution (genetic drift, adaptive radiation, gradualism, punctuated equilibrium, parallelism and divergent/convergent evolution).	Patterns of evolution	1. Have students identify examples of each pattern of evolution. 2. Study sickle cell anemia and how it is is distributed throughout the population. Discuss the advantages and disadvantages of the disease. 3. Have students review the classic study of the peppered moth and industrial melanism. 4. Examine examples of convergent evolution such as birds, bats, and other flying organisms.

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END OF CORE

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
	CLASSIFICATION AND PHYLOGENY	
VII. TAXONOMY AND SYSTEMATICS		
A. BACKGROUND		
97. The student will be able to discuss the history of taxonomy and how the modern system of taxonomy relates to the theory of organic evolution.	Classification, systematics and evolution	1. Have students conduct library research on a taxonomist who contributed to the field of systematics. 2. Have students respond to why taxonomy is important.
B. DICHOTOMOUS KEY		
**98. The student will be able to develop a dichotomous key for a given group of organisms.	Dichotomous key	1. Have students develop a dichotomous key for individuals in the class. Have an outside student use the key to identify a student in the class. 2. Provide students with 12 or more leaves taken from dicot and monocot plants. Students construct a dichotomous key for the identification of the leaves. 3. Reference see lab "Classification and Taxonomy of Animals" by Patterson, Goodenough, 1987. 4. Refer to Cooperative Extension Publication # 1669, "Leaf Key to Common Trees in Louisiana," by Main and Box, used in 4-H for teaching leaf identification.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
C. LEVELS OF CLASSIFICATION		
*99. The student will be able to name the seven major levels of classification.	Classification	1. Review the classification of various animals and plants.
		2. Examine lists of endangered species. Contact the Louisiana Heritage Foundation.
		3. Discuss the importance of the diversity of organisms.
		4. Compare earlier classification and describe why changes have occurred.
**100. The student will discuss the five-kingdom system.	Kingdoms	1. Show students old textbooks describing various taxonomic classifications.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
VIII. MICROBIOLOGY		
A., B., C. MONERA, PROTISTA, AND FUNGI		
*101. The student will be able to distinguish among the three major kingdoms of microorganisms (Monera, Protista, Fungi).	Structure	1. Have students set up a series of bowls or jars containing samples of foods. Examples may be bread, ripe fruit, dried beans in water, cottage cheese, pond water, peppercorns, garden soil, etc. Allow the materials to grow for seven or eight days and examine for the presence of protista, monera and fungi. (See BSCS Green Version - fifth edition - Houghton Mifflin.)
**102. The student will explain the ecological relationship of each kingdom to man and to other organisms.	Interrelationship of organisms	1. Ask students to select groups of animals or plants and demonstrate or describe their relationship to humans.
103. The student will perform laboratory activities involving the growth and identification of organisms from the three kingdoms of microorganisms.	Reproduction and metabolism of microorganisms	1. Set up a lab exercise to illustrate the inhibition of bacterial growth by antibiotics and antiseptics. Antibiotic sensitivity disks may be purchased from biological supply companies. Similar disks may be made from filter paper soaked in various antiseptics.
		2. Determine the bacterial count of various water samples using a serial dilution technique and colony counts.
		3. Determine bacterial tolerance to salt concentration by exposing a pure or mixed culture of bacteria to a series of agar plates containing different levels of salt concentration. Comparisons are made through colony counts.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		4. Students will perform staining and culture laboratories to determine morphological characteristics and colonial growth of bacteria.
D. VIRUSES		
*104. The student will describe the special characteristics of viruses that set them apart from other organisms in the living world.	Viruses	1. Show diagram or picture of various virus groups. 2. Discuss metabolism and replication of viruses.
**105. The student will discuss the ecological relationship of viruses to man and other organisms.	Virus ecology	1. Have guest speakers from local health and sanitation departments to discuss water treatment, control of pathogens and general public health. 2. Identify viruses that are affecting human populations. 3. Discuss the role of arboviruses. 4. Discuss other diseases associated with viruses such as Herpes, cancers, AIDS, and encephalitis.
IX. PLANTS		
A. PLANT GROUPS		
*106. The student will distinguish between the vascular and non-vascular plant groups.	Plant groups	1. Display living and preserved examples of liverworts, mosses, ferns, angiosperm and gymnosperm plants. Have students examine plants, and identify and compare taxonomic structures.
B. TAXONOMY OF PLANTS		
**107. The student will describe the diversity of structure in the taxonomy of plants that include bryophytes, gymnosperms, and angiosperms.	Diversity of plants	1. Have students observe series of prepared slides illustrating structure of stems, roots, and leaves from vascular plants. As an alternative, students could prepare their own

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		slides from plant samples provided by the teacher. 2. Consider developing a plant collection or leaf collection. 3. Develop a survey collection.
C. LIFE CYCLE IN NON-VASCULAR PLANTS		
**108. The student will discuss the life cycle of non-vascular plants, e.g., liverworts, mosses, ferns.	Life cycle of non-vascular	1. Have students bring to class samples of mosses and ferns and identify the stage of the life cycle that they are in. 2. Have students open the capsules of plants and observe reproductive cells under the microscope.
D. ALTERATIONS OF GENERATIONS		
**109. The student will describe alternation of generations in plant groups.	Alteration of generations	1. Conduct a field trip to identify non-vascular plants. 2. Raise non-vascular plants to a reproductive stage.
E. ANATOMY AND PHYSIOLOGY OF VASCULAR PLANTS		
**110. The student will identify and describe the structure and function of vascular plants including leaves, stems, roots, and adaptations to climatic change.	Vascular plants	1. Have the students compare and contrast leaves of subtropical plants and a cactus and or salt marsh plant with plants such as pine, oak, or ferns.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
F. SEXUAL REPRODUCTION		
*111. The student will describe sexual reproduction in flowering plants.	Sexual reproduction	1. Students perform a dissection of flower parts using a variety of flowers, e.g., lilies, black-eyed Susans, daffodils, etc. Students should also be given the opportunity to examine live or preserved examples of complete and incomplete flowers. 2. Students observe the growth of pollen tubes using gelatin mediums of different types of sugars and sugar concentrations. Variables of temperature, light, and kinds of pollen may be studied. (Lab Investigations in Biology - Silver Burdett Company)
*112. The student will discuss the diversity of structure in seeds and fruit.	Structure of seeds and plants	1. Ask students to collect seeds from every plant possible. Separate seeds and identify parts.
*113. The student will describe ways in which seeds are dispersed in the environment.	Dispersal	1. Refer to activities commonly found in Biology I.
G. ASEXUAL REPRODUCTION		
*114. The student will describe types of asexual reproduction in flowering plants.	Asexual reproduction of flowering plants	1. Refer to activities commonly found in Biology I. 2. Compare asexual methods of reproduction.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
H. RESPONSES		
**115. The student will describe plant responses to environmental stimuli.	Plant response	1. Conduct experiments showing how various environmental stimuli affect plant growth. 2. Develop hypothetical experiments.
I. PLANT HORMONES		
**116. The student will describe the role of plant hormones in the regulation of growth and response to environmental stimuli.	Plant hormones	1. The Effect of Environmental Factors on Seed Germination. (Laboratory 1-3 p. 81-82. Biology, Macmillan Publishing Co., Inc.) Involves placing seeds in petri dishes and subjecting to various environments - (cold-light) (cold-dark)(warm-light)(warm-dark) (controls). 2. Plant Responses to Environmental Stimuli - (Activity 14-D--Biology Laboratory Manual, Scott Foresman & Co.) Demonstrates phototropic response of radish seedlings. Observe geotropicresponse of corn seedlings. Seek evidence of magnetic field effect on cornplant growth. Refer to McCormack, Alan J. "Magnetotropisms." The Science Teacher. Vol. 40, No. 1, (January, 1973) and Vol. 40, No. 5, (May, 1973). Refer to Teacher's Guide to Advanced Placement Courses in Biology. Copies may be purchased from the College Board.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		3. Students set up an experiment to illustrate the effects of gibberellic acid on plants. Alaskan and Little Marvel peas are suggested as possible plant types. A control and experimental group of plants are used. The experimentals are treated with 100 mg/liter gibberellic acid and a daily record of growth is maintained. (See BSCS Second Course - Interaction of Experiments and Ideas).
		4. Students test the effects of IAA on coleoptile or pea stem elongation. Pea stems or coleoptiles sections of equal length are placed in petri dishes containing various concentrations of IAA (indole acetic acid). Growth is recorded on a data sheet. (See BSCS Second Course - Interaction of Experiments and Ideas).
J. PHOTOPERIODICITY		
**117. The student will discuss photoperiodicity in plants and how it affects growth.	Photoperiodicity	1. Students set up an investigation to show the effects of light on seed germination. Does light promote, inhibit, or have no effect on seed germination? Students use light sensitive and light insensitive seeds. Example is Great Lakes and Grand Rapids Lettuce seed. Control and experimental groups are set up and observation of number of germinating seeds are made. (One group exposed to light prior to germination--one group kept in the dark at all times). (See BSCS Second Course - Interaction of Experiments and Ideas.)

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
X. ANIMAL DIVERSITY		
A. INTRODUCTION		
1. Radial Symmetry		
**118. The student will be able to describe the morphological and physiological characteristics of radially symmetrical animals: cnidaria and ctenophora.	Radial symmetry	1. Review Biology I activities or laboratories.
2. Bilateral Symmetry		
**119. The student will be able to describe the morphological and physiological characteristics of bilaterally symmetrical aceolomates, pseudocoelomates, and coelomates.	Bilateral symmetry	1. Review Biology I activities or laboratories.
**120. The student will be able to draw a distinction between invertebrate and vertebrate animal groups and discuss them.	Vetebrate vs. invertebrate biology	1. Students perform comparative dissections of various animal groups. Compare and contrast body systems of animal groups.
B. INVERTEBRATES		
**121. The student will be able to describe the morphological and physiological characteristics of the following phyla: porifera, cnidaria, platyhelminthes, nematoda, annelida, mollusca, arthropoda, echinotermata, chordata.	Comparative invertebrate systematics	1. Students perform comparative dissections of various animal groups, compare and contrast body systems of animal groups.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
C. VERTEBRATE DIVERSITY		
122. The student will be able to recognize the characteristic morphological and histological differences among the classes of vertebrates. (Agnatha, Chrondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, Mammalia)	Diversity of vertebrates	1. Have students prepare or use prepared slides to observe and compare different types of tissues. Attention should be given to structure and function. 2. Students perform comparative dissection of various animal groups. Compare and contrast body systems of animal groups.
D. VERTEBRATE HOMEOSTASIS		
**123. The student will be able to describe homeostasis in vertebrates, e.g., excretion, respiration, temperature regulation.	Homeostasis in vertebrates	1. Discuss with students the concept of stenohaline and euryhaline to introduce students to salt glands. 2. Students perform respiration experiments dealing with oxygen consumption and CO$_2$ production. Variables to study may include: respiration rate vs. body mass, rates of respiration in terms of environmental temperature, comparison of endothermic and exothermic animals' rates of respiration. Animals such as white mice, lizards, or frogs may be used. Respiration chambers may be constructed from bottles or jars or purchased from supply companies. For additional details on lab preparation, see BSCS Second Course - Interaction of Experiments and Ideas, Teacher's Guide to Advanced Placement Biology, BSCS Blue Version Text, Investigating Living System Lab Manual by Merrill.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
XI. COMPARATIVE PHYSIOLOGY		
124. The student will be able to compare the physiology of the transport systems among the vertebrates and invertebrates.	Comparative anatomy and physiology	1. Students conduct exercises dealing with properties of enzymes. Experimental design should include ways of illustrating the effects of temperature and pH on enzyme activity. The source of the enzyme may vary--it is suggested that students extract their own from such sources as barley, wheat seeds, or dry yeast, all of which contain starch and sugar splitting enzymes. For experimental design refer to Teacher's Guide to Advanced Placement Biology, BSCS Second Course Biology, Investigating Living Systems Lab Manual by Merrill, Scott-Foresman Biology Lab Manual).
**125. The student will be able to compare the physiology of the muscle system among the vertebrates and invertebrates.	Comparative anatomy and physiology: muscles	1. Students should conduct a comparative laboratory to compare muscle groups of vertebrates and invertebrates.
**126. The student will be able to compare the physiology of the nervous system among the vertebrates and invertebrates.	Comparative anatomy and physiology: nervous system	1. Use models of cranial and spinal nerves. 2. Cerebro-spinal reflex. Gently pinch the skin at the nape of the neck. Note the reaction of the pupils of the eyes. 3. Use microscope section of spinal cord. 4. Write your name with your right hand three times. Write your name with your left hand. What causes the different results? Why are habits hard to break?

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**127. The student will be able to compare the physiology of the digestive system among the classes of vertebrates.	Comparative anatomy and physiology: digestive	1. Refer to Kent's Anatomy of the Vertebrates and study comparative features. 2. Have students collect teeth from other vertebrates and compare to human teeth.
**128. The student will be able to compare the physiology of the reproductive system among the classes of vertebrates.	Comparative reproduction	
**129. The student will be able to compare the physiology of the excretory system among the classes of vertebrates.	Comparative anatomy and physiology: excretory system	
**130. The student will be able to compare the physiology of the endocrine system among the classes of vertebrates.	Comparative anatomy and physiology: endocrine system	1. Compare reproductive organs of the shark, the mud puppy (Necturus), and the lamprey. 2. Discuss advantages of each type of system.
XII. COMPARATIVE EMBRYOLOGY		
**131. The student will be able to make comparisons in the development of vertebrate animals.	Comparative embryology	1. Set up an observational lab dealing with hormonal control of the development of frog embryos. Tadpoles are placed in a series of bowls containing different combinations and concentrations of thyroxin, triiodothyronine and iodine. Students observe the stages of metamorphosis over a

period of several days. (See 1965 edition of BSCS Second Course Biology or Laboratory Investigations in Biology - Silver Burdett Company).

2. The BSCS Second Course text, 1965 edition contains a lab dealing with the effects of testosterone and gonadotrophin on the development of chicks. Baby chicks are given daily injections of the hormones for 8-10 days and observations on the development of the chicks are compared--Controls vs. Experimentals. If this activity is used, teachers should insure that all appropriate steps are followed involving using live animals for experimentation in the classroom.

3. Investigate the effects of pituitary hormone stimulation on egg laying in female frogs. This may be followed by a study of frog egg development and frog embryology. (Laboratory Investigations in Biology - Silver Burdett Company.)

4. Embryology slides may be used to study stages of embryo development. Slides showing frog or salamander development works well. Films or filmstrips that illustrate stages of development may be used. Teachers may display a series of preserved chick embryos ranging from a three-day-old embryo to 18 or more days. (A good reference is Biology--An

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		Appreciation of Life, CRM Books.
XIII. ANIMAL BEHAVIOR		
*132. The student will be able to identify some common terms and influential people in the area of animal behavior, e.g., ethology, motivation, pheromones, drives, Lorenz, Pavlov, Thorndike, etc.	History	1. Have students conduct library research and report on key individuals or concepts. 2. Explore concepts of sociobiology as described by E. O. Wilson.
133. The student will be able to compare and contrast innate and learned behaviors in animals.	Learned and innate behavior	1. Use National Geographic Films - "Mystery of Animal Behavior" and "Science of Animal Behavior" to illustrate the wide varieties of learned and innate behaviors. 2. Cite reactions of Land Isopods (Pill Bugs) to light and humidity. From Teacher's Guide to Advanced Placement Course in Biology, 1984. Pill bugs demonstrate negative phototaxis. Make directed movements away from areas of greater illumination toward dark areas. Pillbugs increase their locomotor activity under dry conditions and wander quite randomly and decrease their activity under preferred humidity conditions. Thus they tend to aggregate in damp places. 3. Students perform exercises using daphnia or brine shrimp to illustrate behavior responses to light, temperature or pH. (Teacher's Guide to Advanced Placement Course in Biology.)

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
134. The student will distinguish between different types of innate behaviors in animals.	Innate behavior	4. Use Hermit crab or similar animal to show territoriality. 5. Discuss with students their pets and territoriality.
135. The student will distinguish between different types of learned behaviors in animals, e.g., habituation, trial and error, insight, conditioning, imprinting.	Learned behavior	1. Have student discuss experiences training dogs, cats, or other pets.
**136. The student will discuss the role of hormones in animal behavior. (Biorhythms)	Physiological response and behavior	1. Have students discuss mood changes affected by hormonal changes and physiological factors.
XIV. ECOLOGY		
A. ENVIRONMENT		
*137. The student will be able to define environment as a combination of external conditions that influence the life of an individual, organism, or population.	Environment definition	1. The students will individually list 5 or more external conditions that influence their lives. 2. Use the quote "when we try to pick out something by itself, we find it hitched to everything else in the universe," to stimulate class discussion about the importance of studying the environment. 3. As a class, students will discuss their individual lists of external conditions and compile a list representing the class as a population.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		4. Stimulate a discussion as to how these external conditions would affect organisms such as trees, other plants, their pets, insects, and other organisms.
*138. The student will be able to recognize that the definition of ecology is the interrelationship of organisms to their environment.	Ecological concept	1. Have students select 10 diagrams, 5 of different animals and 5 of different plants. This group would represent level one, the organism. Students will then divide the plants and animals into groups of similar organisms (2nd level-population). Then have students determine what populations do exist together and group these to form a community (3rd level). Continue this progression from community to ecosystem to the biome and biosphere level. Use old magazines.
**139. The student will demonstrate an understanding of the relationship between environment and ecology by listing and discussing external conditions connecting their environment.	Ecological concept	1. As a class, students will discuss their individual lists of external conditions. Compile the list. 2. Discuss how these external conditions affect other populations within the community.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
B. ECOLOGICAL ORGANIZATION		
*140. The student will be able to describe the levels of ecological organization of: a. biosphere b. biome c. ecosystem d. community e. population f. organism	Ecological system	1. Have students examine examples of each level. At the biome and ecosystem level, students might bring slide pictures from home showing different kinds of habitats. 2. Students may use globes or world maps to demonstrate location of various biomes.
**141. The student will describe characteristics of ecological succession.	Ecological succession	1. If copies of the BSCS Green Version Biology text is available, have students work the problem questions associated with the activity dealing with the effects of fire on biomes. In this exercise, students are given a series of pictures depicting different biomes before and after a fire. Questions are presented regarding the effects of the fire.
*142. The student will list and describe characteristics of Earth's major biomes.	Biomes	1. Students construct climatograms illustrating the yearly rainfall and temperature in selected biomes. Climatic data for this may be obtained from the local weather stations or from sources such as BSCS Green Version Text. 2. Show films, slides, or pictures of each. Students should be asked to identify the characteristics of each.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
*143. The student will be able to define biosphere as the portion of the earth and its atmosphere capable of supporting life.	Ecological system: biomes	1. Have students draw a parallel between the skin of an apple and the biosphere.
*144. The student will be able to list the major biomes.	Ecological system: biomes	1. Show films, slides, or pictures of each. Students should be asked to identify the characteristics of each.
*145. The student will be able to define an ecosystem as a natural community of organisms interacting with one another and with their environment	Ecological system: ecosystem	1. Ask students to identify a component in the environment (like mosquitos) that we could live without. Encourage the students to consider what other population in their environment might require that component. (An example might be the dependence of small fish on mosquito larvae for food.) 2. Examine the school "ecosystem" as a small community and identify its interacting components.
*146. The student will be able to define and identify a community as a group of populations occupying a particular habitat or area.	Ecological system: community	1. Students may conduct a field trip either in school or for homework and identify communities found.
C. ENERGY PATHWAYS		
**147. The student will explain energy pathways through living systems, e.g., food chains, food webs, energy pyramids, carbon budget, and energy flow.	Energy pathways	1. Have students discuss the source of all energy and link it to the food they eat.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
D. BIOGEOCHEMICAL CYCLES		
148. The student will describe biogeochemical cycles and explain their importance to living systems. These should include: water cycle, oxygen cycle, nitrogen cycle, carbon cycle, sulfur cycle, phosphorous cycle.	Biogeochemical cycles	1. Have student examine each cycle and determine how they are affected by each.
*149. The student will be able to distinguish the difference between the terms "habitat" and "niche."	Ecological system: habitat and niche	1. Students may conduct a field trip either in school or for homework and identify various habitats and the niche of certain organisms living in those habitats.
**150. The student will be able to recognize and identify various kinds of habitats and niches.	Ecological system: habitat	1. Discuss various types of habitats and niches showing films and pictures. 2. Collect plants and animals that are typical of the various habitats found in Louisiana. 3. Assign students the study of various habitats and have them report on them.
E. COMMUNITIES		
**151. The student will describe the dynamics of a community including such factors as coevolution, predator-prey relationships, and symbiosis.	Community dynamics	1. Have students develop hypotheses regarding the evolution of specific feeding behaviors. 2. Examine paleontological evidence of ancient feeding strategies.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
F. POPULATION DYNAMICS		
**152. The student will be able to define population as a group of organisms of the same species.	Ecological system: populations	1. Students may conduct a field trip either in school or for homework and identify various populations of organisms found.
**153. The student will describe the impact of biotic and abiotic factors on populations.	Population limits	1. Have students grow a laboratory population of yeast cells. The exercise can be set up so that daily counts of the population can be obtained for a 8-10 day period. The final results can be plotted on a graph to show the stages of growth of the population. For details involving the lab setup refer to: BSCS Second Course Text or Investigating Living Systems Lab Manual - Merrill Publishing Company.
		2. Students set up quadrat studies to determine population densities and types of populations found in a given area. This may include field collecting plant and animal specimens to be studied at a later date in the lab.
		3. Soil samples may be collected during the quadrant studies and students set up a Berlese apparatus to extract soil nematodes.
		4. Have students collect water samples from various sources. These samples may be tested for dissolved oxygen. (Preparations of reagents and procedures to follow may be found in BSCS Green Version Text--Teacher Ed. 1982 Ed. Houghton Mifflin or Investigations into Living Systems Lab Manual - Merrill Publishing Company).

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		5. Students measure dissolved oxygen content of two water samples at 10° and 60°C. A determination can be made as to the effects of temperature on dissolved oxygen in water.
*154. The student will describe the concept of carrying capacity.	Population	1. Ask students to predict what their community would be like if their community population doubled or tripled.
**155. The student will describe stages of growth of a population.	Population growth	2. Discuss issues such as housing, food, and lifestyles. 3. Follow up with simulation. 4. Reference: Global Science, 1985, "Activity on Space Trip." 5. Contact NASA regarding space travel. 6. Examine demographic differences between countries such as Denmark, Finland, and Norway. Compare to the United States, Mexico, and Ethiopia.
156. The student will demonstrate an understanding of the early ideas of population growth.	Over-population	1. Assign students material to read about Malthus' Theory. 2. Discuss Malthus' predictions and why they have not come to pass. 3. Discuss why eventually his predictions could come to pass.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
157. The student will be able to list several principles pertaining to the organization of population levels. These would include: a. Density--population size in relation to some unit of space b. Natality--inherent reproductive ability of a population c. Mortality--death of individual of a population d. Age distribution--range of groups within the population e. Fecundity--capability of reproducing offspring (females)	Population group properties	1. Study population structures of different organisms. a. ants, termites, bees b. roaches c. birds (starlings, California Condor) d. grizzly bears e. humans 2. Study the demographic structures of western Europe, Egypt, India, Japan, Malaysia, Canada, and the United States. Draw bar charts to show distributions. 3. Obtain population information about shifts in population: age shifts, ethnic shifts, and nationality shift. Discuss how these alter populations.
158. The student will be able to draw and interpret an idealized population growth curve, a logarithm curve, exponential growth, and "plateau effect."	Population density	1. Use a calculator to demonstrate the concept of exponential growth with the analogy of the increase of money in an interest-bearing savings account. 2. Discuss the "Tragedy of the Commons" and how it relates to the global picture.
159. The student will be able to describe geometric population growth and contrast it with arithmetic growth.	Growth patterns of a population	1. Draw a graph showing examples. Use data to graph accurately examples to be used: - growth of a bean plant - growth of an insect population of locusts - growth of a population of hawks 2. Conduct a "modeling exponential growth" laboratory. Use graph paper to demonstrate the concept of exponential growth.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
160. The student will be able to explain how to estimate a population growth by using: a. extrapolation b. prediction	Estimating population growth	1. Using the predicting methods, estimate a population growth or change if global nuclear war took place--rat population, roach population, human population.
161. The student will be able to demonstrate that the carrying capacity is determined by the availability of materials and conditions necessary for maintaining a particular kind of organism and that the earth's carrying capacity is limited for all species, including man.	Carrying capacity	1. Estimate the carrying capacity of the city or town in which the students live. Estimate how many students could live in an area the size of their class room. Discuss waste disposal, food, water and other resources.
162. The student will recognize various types of feeding strategies and their effects on populations, e.g., specialized feeder, opportunistic, etc.	Feeding strategies	1. Compare feeding strategies with evolutionary patterns.
163. The student will describe how mortality, fecundity (number of reproducing females) and other demographic factors affect population growth.	Demographic factors	1. Develop charts that show how mortality, fecundity, and other demographic factors have affected population growth.
G. Human Ecology		
164. The student will be able to describe human cultural evolution	Population growth	1. Discuss controversies surrounding predicted trends. Assign students

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
and its impact on human populations. This should include the development of agriculture.		readings about various industrial periods that may have affected the present population, and point out what specific factors may have directly altered population growth.
**165. The student will discuss biological factors affecting population such as: a. nutrition b. disease c. famine d. death rate e. birth rate	Population growth	1. Discuss biological factors and how they affect a population and the individual.
**166. The student will be able to recognize why the world's human population increases despite a simultaneous decrease in the birth rate.	Total fertility rate	1. Show students how a decrease in the birth rate affects only one of the factors affecting population growth. Use a matrix to show various factors.
167. The student will be able to recognize the effect increasing population has on the social structure of a civilization.	Effect of population growth on social structure	1. Have students make a comparative demographic study of countries which have a high population density, moderate population density, and low population density (China, the United States, and Australia).
168. The student will be able to recognize the cultural factors affecting population levels.	Cultural factors and population	1. Have students discuss issues that might reduce population growth. Have students examine population growth patterns of Western Europe, North America, Latin America, Africa, and Asia to determine differences that might affect their growth.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
169. The student will be able to discuss the effect of urbanization on population levels.	Urbanization	1. Examine how urbanization affects population levels, then predict trends in population growth.
170. The student will be able to recognize that all organisms have the capability of reproducing beyond the availability of food resources.	Population and food supply	1. Have students conduct the Drosophila melanogaster experiment that simulates population growth under specific conditions.
*171. The student will identify and describe renewable and nonrenewable resources and give examples of each.	Renewable and nonrenewable resources	1. Have students list examples of renewable and nonrenewable resources. 2. Predict changes in resources over the next 2,000 years. 3. Consult the global 2,000 report producer under President Carter's administration and compare and contrast President Reagan's administration study on the environment.
172. The student will identify energy sources available to humans, their role in society, and their levels of efficiency.	Energy	1. Examine types of energy used throughout the world. Examine levels of efficiency by modern and third world nations.
H. Pollution		
**173. The student will be able to recognize natural and manmade sources of pollution and their impact on man and his environment.	Natural pollution	1. Examine sources of extinction of dinosaurs and other forms of life. Describe what has happened over the past several thousand years within the Tigris-Euphrates Valley. Describe the volcanic eruptions of

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		Mount Vesuvius, Krakatoa, and more recently, of Mount St. Helens. See issues of National Geographic or other related articles. Videotapes on Mount St. Helens and Krakatoa are available.
**174. The student will be able to describe various types of man-made pollution over the past thousand years. These include sources of air pollution, water pollution, and his environment.	Man-made pollution	1. Discuss sources of pollution found in ancient caves and irrigation sites and the contamination of food and water during the medieval period. 2. Describe what has happened concerning pollution over the past several hundred years since the industrial revolution, and discuss how changes in man's life style have precipitated much of today's attitude about the environment and pollution. 3. Contact local environmental organizations and industries to discuss local man-made pollution.

OBJECTIVE	**CONCEPT**	**SUGGESTED ACTIVITIES**
	VERTEBRATE ANATOMY AND PHYSIOLOGY	
VII. ORGANIZATION OF THE VERTEBRATE BODY		
A. FIELDS OF VERTEBRATE STUDY		
175. The student will describe the history of vertebrate study and identify various fields of work.	Fields of vertebrate study	1. Discuss with students the methods used to study the human body 1,000 years ago. Compare changes that have occurred.
B. THE ORGANIZATION OF THE VERTEBRATE BODY		
*176. The student will describe the various levels of structural organization within the vertebrate body.	Vertebrate body organization	1. Have students label diagrams of the anatomical divisions of an invertebrate body, a vertebrate other than human, and the human body.
*177. The student will recognize basic directional terms used in anatomy and physiology.	Vertebrate body organization	1. Use a chart to demonstrate the structural organization of the body. 2. Use non-biological examples for students to use to identify various parts. (ex. Front, back, top, and bottom and side. Equate these terms with dorsal, ventral, lateral, etc.)
*178. The student will identify the various body cavities.	Body cavities	1. Use the body of a chicken, turkey, or other animal to demonstrate the various body cavities.
*179. The student will list the ten body systems.	Body systems	1. Have students list and identify body systems for several animals. Use labs and various animals.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
C. COMPARATIVE INTERCELLULAR ORGANIZATION AND DEVELOPMENT		
180. The student will define and differentiate between the various tissues, e.g., epithelial, muscular, connective, and nervous and tell how they form organs.	Tissue differentiation	1. Obtain prepared microscope slide of the four main tissue types (epithelial, muscular, connective, nervous). Have students make drawings of the different cell types involved.
181. The student will explain the characteristics of the three basic epithelial tissues and describe where they are found.	Characteristics of tissues and organs	1. Contact local hospitals of veterinary clinics for samples of tissues. 2. Repeat cheek cell activity to observe squamous cell epithelial tissue. 3. Obtain slides of tissues of the lower animals (such as hydra, sponge, nematodes) and compare those to the tissue layers in humans. 4. Use the structure and tissues of an uncooked chicken wing and compare to a human arm. 5. Discuss the possibility of using artificial cells in human tissues. What kinds of problems do students foresee in using these?

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
VIII. THE SUPPORTING FRAMEWORK AND MOVEMENT		
A. SKELETON DEVELOPMENT		
**182. The student will be able to list four functions of the skeletal system and compare these functions to each class of vertebrates.	Functions of skeleton	1. Obtain a fresh beef bone from a butcher. Have it cut lengthwise to observe internal structures.
**183. The student will be able to identify structural parts of a typical long bone found in all vertebrates.	Structure of long bones	1. Obtain cow, horse, flying bird bones and compare the external and internal structures of those with human bones.
**184. The student will be able to distinguish between the axial division and the appendicular division of the skeleton and recognize the bones in each.	Axial and appendicular skeleton	1. Compare advantages and disadvantages of exoskeletons and internal skeletons. 2. Compare various animals and describe the division of each.
B. PHYSIOLOGY		
**185. The student will be able to identify the six types of joints and give examples of each.	Joints and action of joints	1. Conduct a laboratory during which students examine skeletons of various animals and identify all joints.
		1. Get fresh muscle and bone preparations to compare tendon structure to ligaments.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
*186. The student will be able to distinguish between a ligament and a tendon.	Ligaments and tendon	1. Have students describe basic disorders of joints and examine old bones for signs of disease. 2. Soak chicken bone in nitric acid to show how minerals can be removed from bone. Purpose is to show how minerals contribute to hardness and rigidity of bone. This will isolate areas of bone where joints are located.
IX. MUSCLE TISSUE		
A. ANATOMY AND HISTOLOGY		
**187. The student will be able to describe the three muscle types.	Anatomy of skeleton muscle	1. Obtain muscle tissue of the three muscle types (cardiac, smooth, skeletal) and make drawings of each. Various muscle types may be purchased or obtained from slaughter houses, fish catches, etc.
**188. The student will be able to compare the differences in the histology of the three muscle types.	Histology of skeleton muscle	1. Have students microscopically examine the three muscle types. Samples of muscles may be obtained from pathology laboratories.
B. Physiology		
189. The student will be able to describe the events that take place during a muscle twitch.	Physiology of muscle twitch	1. Obtain a fresh sample of the gastrocnemius muscle of frog. Illustrate muscle twitch using electrical stimulation. Use a kymograph computer transducer to record data. Alternate current.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
190. The student will be able to explain the mechanism of muscle fiber contraction.	Physiology of muscle contraction	1. Cool a gastrocnemius muscle in refrigerator, then time muscle contraction time as compared to warmer, room-temperature time. 2. Write your name three times. Hold ice cubes to hand for three minutes. Now write your name three times. (Effect of temperature on muscle). Warm your hand by massaging it or putting in hot water. Write your name three times. Compare results. (a) Close and open your hand quickly and strongly. Count the number you do in 30 seconds. Repeat 10 times. Graph your result by plotting number of closures/trial on the vertical scale and of trials on the horizontal scale. (b) Now place blood pressure cuff around arm to restrict radial blood flow. Open and close for 30 seconds. Compare with results in (a). 3. Apply chemicals such as acetylcholine and adrenalin to pithed frog muscle (gastrocnemius). 4. Use bromthymol blue to determine carbon dioxide content released by muscle activity. 5. Place arm resting on table with palm up. Place an extremely heavy object on palm. Try to lift, but do not. Feel muscle in upper arm.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		6. Place arm again on table as in (A). Place book on hand and lift. Feel muscle in upper arm. Note difference between isometric and isotonic contractions.
C. SKELETAL MUSCLES		
**191. The student will define origin and insertion and identify skeletal muscles in the vetebrate body.	Origin and insertion	1. Identify origin and insertion of major muscles.
		2. Assemble a model of humerus and forearm. Attach strings at origins and insertion points to show how muscles affect bone movement.
		3. Design several simple exercises that specifically involve movement of muscles found in arms, shoulders, chest, back, and legs.
*192. The student will explain the function of antagonistic muscle groups.	Antagonistic muscles	1. Show color plates of superficial muscles.
		2. Press toes of right foot on floor and raise yourself. (a) What happens to the calf of your leg? (b) What effect does this movement have on the position of the heel of the foot? (c) Feel the tendon when the foot is extended and when it is flexed at the ankle. (d) Flex the foot sharply at the ankle and feel the effect on the muscles on the front of the leg. (e) Explain why these tendons do not bulge between the muscles and the bones of either the foot or the hand.
		3. Have students contact muscular distrophy office or the Parish Health Office for literature concerning the disease.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
193. The student will identify functions of the skeletal muscles within the classes of vertebrates and compare their functions.	Comparative muscles	1. Students should conduct a comparative laboratory to compare muscle groups of several classes of vertebrates. 2. Invite a coach or physical education major to talk about weight lifting and how it affects the muscles.
X. COORDINATION AND CONTROL OF BODY		
A. NERVOUS TISSUE		
*194. The student will describe the general structure of a neuron.	Neuron structure	1. Have students examine histological slides of neurons. 2. Reflex timing. Drop a dollar bill. Try to catch it between two fingers.
**195. The student will understand the way in which structure and function are used to classify different kinds of neurons.	Neuron classification	1. Use a buzzer to enhance reaction time. Ask questions as in a Quiz Bowl.
**196. The student will summarize the activities that lead to the transmission of a nerve impulse.	Nerve transmission	1. Reflex timing. Drop a dollar bill. Try to catch it between two fingers. 2. (a) Knee jerk, or patellar reflex. The subject should sit on edge of table. Strike knee below patella. (b) Same as (a) except have student interlock fingers and try to pull them apart just as blow is struck. Muscular tension affects reflex responses. 3. Have a student hold a glass plate up in front of his face. Have another student throw a paper wad at his face. Note reaction.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
B. NERVOUS SYSTEM		
*197. The student will name two major divisions of the nervous system.	Nervous system	1. Use models of cranial and spinal nerves.
198. The student will describe the structure and function of the spinal cord and compare spinal cords of various classes of vertebrates.	Spinal cord	1. Cerebro-spinal reflex. Gently pinch the skin at the nape of the neck. Note the reaction of the pupils of the eyes. 2. Use microscope section of spinal cord.
**199. The student will identify parts of vertebrate brain and their function and compare the anatomy of various classes of vertebrates.	Comparative anatomy of brain	1. Write your name with your right hand three times. Write your name with your left hand. What causes the different results? Why are habits hard to break?

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**200. The student will distinguish between the motor, sensory, and associative areas of the cerebral cortex.	Cerebral cortex	1. (a) Knee jerk, or patellar reflex. The subject should sit on edge of table. Strike knee below patella. (b) Same as (a) except have student interlock fingers and try to pull them apart just as blow is struck. Muscular tension affects reflex responses.
*201. The student will name two major parts of the peripheral nervous system.	Peripheral nervous system	1. Compare a plastic model of human brain to a preserved sheep or cat brain. Identify various parts.
202. The student will identify the 12 pairs of cranial nerves.	Cranial nerves	1. Color plates of neuron, brain, and cranial nerves.
203. The student will describe how depressant and stimulant drugs work on the CNS.	Effects of drugs on CNS	1. Show films on how alcohol (AA) reduces reaction time. 2. Use caffeine experiments to demonstrate change in activity of the heart. Have several student volunteers drink several cups of coffee and measure changes in heart rate before and after. (Obtain parental permission for the volunteers before activity.)
C. VISION		
204. The student will identify the embryonic eye and describe the development and function of each part.	Eye	1. Use a model of an eye or acquire a sheep or cow eye.
*205. The student will describe how the light-sensitive cells and the rods and cones function.	Rods and cones	1. Use light to show pupillary reflex. 2. Have students cover both eyes.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
206. The student will summarize the way in which the light waves passing through the various structures of the eye are converted into nerve impulse.	Physics of sight	1. Have students cover both eyes for two minutes. As both eyes open have them observe the size of the pupils when exposed to light.
207. The student will define the terms refraction, convergence, accommodation and how they relate to vision.	Opthamology and diseases of the eye	1. Use lens from a physics class to demonstrate how the slope affects the focus of the eye.
D. HEARING		
208. The student will use evidence from comparative anatomy and developmental biology to explain the structure and function of the different divisions of the ear and how they developed.	Ear	1. Use a model of an ear that has removable parts.
		2. Emphasize the delicate structure of the organ of Corti, obtain a prepared microscope slide of the cochlea.
		3. Conduct a comparative laboratory using other classes of vertebrates.
		4. Emphasize the delicate structure of the organ of Corti, obtain a prepared microscope slide of the cochlea.
*209. The student will trace the path of sound waves through the organ of the ear to the brain.	Transfer of sound	1. Use a model of an ear that has removable parts.
		2. Obtain an oscilloscope. Play a record that has frequencies from 20 to 20,000 cps. Students note the range of hearing. Oscilloscope shows presence of inaudible frequencies.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**210. The student will explain equilibrium and describe how the structures function in the various classes of vertebrates.	Equilibrium	1. Balance. Stand on one foot. Note movements. Keep balance. Do you think an athlete or dancer would have as great a movement? 2. Have a student turn on heel 10 times. Attempt to touch nose with finger.

XI. COMPARATIVE DIGESTIVE SYSTEM OF VERTEBRATES

A. FOOD AND NUTRITION

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**211. The student will understand the importance of vitamins and minerals in terms of their primary sources, functions, and deficiency disorders.	Nutrition: vitamins and minerals	1. Discuss with students some of the following topics about which there are misconceptions. Some questions to ask about the information concerning the misconceptions are: a. What is the source? b. What is the claim? c. Does the concept agree with other facts about nutrition that you have learned? d. What is the evidence to support the claim? e. What do other authorities have to say about the information? Possible misconceptions are: f. Megadoses of vitamins are effective in treating colds. g. Natural vitamins are more effective than synthetic vitamins. h. The athlete has a greater need for protein. i. Weight control diets are healthy ways to control obesity. j. Chocolate and fatty foods are responsible for acne. k. Natural foods are nutritionally better than processed foods.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**212. The student will describe the function of enzymes in the vetebrate body.	Enzyme activity	1. Have students conduct library research on the different types of enzymes present, and their different functions.
B. MOUTH, PHARYNX, ESOPHAGUS		
213. The student will compare the anatomy of the mouth, pharynx, esophagus among vertebrates.	Anatomy	1. Refer to Kent's Anatomy of the Vertebrates and study comparative features.
214. The student will compare the development of teeth among vetebrates and explain the development of deciduous and permanent teeth.	Physiology and histology	1. Have students collect teeth from other vertebrates and compare to human teeth.
**215. The student will describe the location of the salivary glands and the function of their secretion.	Salivary glands	1. Chew an unsalted cracker until liquified. Do you notice any change in flavor?
		2. Discuss Pavlov's dogs.
		3. Digestion of starch. Chew a rubber band; collect saliva in two test tubes. Add saliva to first, nothing to second. In a third tube add only starch. Add Benedict's to all three. Note changes.
		4. Touch your neck above the larynx as you swallow. Can you swallow without the larynx moving?
**216. The student will identify tastebud locations in humans and discuss chemoreception in other classes of vetebrates.	Tastebuds	1. Dip a swab in a weak solution of salt, sugar, or vinegar. Touch to various places on the tongue. Record sensation and where it appears. Map the distribution of sensations.
		2. Dry off tongue. Place a cracker on the tongue. See if student can taste it.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
C. STOMACH		
217. The student will describe the anatomy and the histology of the stomach and compare it to various mammals.	Structure	1. Use histology slides to demonstrate tissue.
218. The student will identify the components and function of gastric juice and explain the mechanism by which gastric secretion is regulated.	Physiology	1. Compare the neutralizing effects of several antacids on HCl. 2. Place a stethoscope over the surface of the abdomen along the lower left rib. Chew a cracker with a small amount of water. Listen for the entrance of the food into the stomach. Swallow water in rapid succession and listen for the arrival into stomach. 3. Digestion of protein. Use solid egg (white) albumin and add diluted HCl and pepsin. Six testtubes. (a) Pepsin (b) HCl (c) Pepsin and HCl (d) Pepsin and sodium bicarbonate (e) Pineapple juice (f) Heated (37°) pineapple juice Incubate for 24 hours. Note results.
D. INTESTINES		
**219. The student will describe the anatomy of the peritoneum, the small intestine, and the large intestine.	Lower digestive tract	1. Length of intestines. Get piece of rope nine meters long. Attach paper outlines of organs at various points. Have student arrange it so it fits into abdominal cavity. 2. Disection of mammal to study digestive tube, lower pancreas.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
220. The student will describe the composition and the function of each of the intestinal secretions.	Intestinal secretions	1. (a) Mix two drops of Sudan III with 5-10 ml of olive oil. In another beaker, mix 10 ml of water and methylene blue. Add small amount of bile salts. What do you observe? (b) Pancreatic digestion. Place egg white solid into Mett tube. Pour into three petri dishes. To one add pancreatic juice, another pancreatic juice + .4m HCl, third in distilled water. Incubate 24 hours. Measure columns. Note changes.
**221. The student will describe the mechanisms that regulate enzyme secretions.	Enzyme	1. Examine sources of enzyme production.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
XII. COMPARATIVE RESPIRATORY SYSTEMS OF VERTEBRATES		
A. RESPIRATORY ORGANS		
222. The student will compare structures of the nose, nasal cavities, and pharynx, trachea, bronchi, and bronchioles among the classes of vertebrates.	Respiratory system	1. Obtain fresh lungs and trachea from calf. Observe bronchi and bronchioles. Note extensive blood supply.
**223. The student will describe the functions of the larynx and pleural membranes.	Function of larynx and pleural membrane	1. Discuss why coughing occurs. 2. Investigate diseases associated with the pleural membranes. 3. Describe how sound is emitted from the throat.
B. BREATHING MECHANICS		
**224. The student will explain the mechanism of air movements during inspiration and expiration in each class of vetebrates.	Air Movements	1. Use a stethoscope to hear air going into and out of the lungs. 2. Make a miniature respiratory system using a straw, plastic cup, balloon, and rubber sheets. 3. Demonstrate CPR and ask students to determine why it is effective.
		1. Have the students compare the respiratory air volumes under normal and forceful breathing efforts. 2. Measure the circumference of the thorax during inspiration and then again after expiration. Note the difference.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
		3. Conduct an experiment using balloons to determine tidal air, supplemental air, commental air, and residual air, and vital capacity.
		4. Run or exercise and then count the number of breaths per minute. Calculate the respiration rate per minute.
		5. Discuss the use of a pressure chamber for treatment of gangrene, or in diving injuries such as "bends."
		6. Have student demonstrate major artificial respiration techniques.
C. RESPIRATORY PHYSIOLOGY		
225. The student will explain the function of the gas laws in respiration. (Dalton's Law and Boyle's Law)	Physiology of breathing	1. Use diagrams or visual aids to show relationship between O_2 - CO_2 exchange.
	Physiology of respiration	1. Exhale into calcium hydroxide or barium hydroxide--precipitate forms--calcium carbonate--shows presences of CO_2 in exhaled air.
**226. The student will identify the differences between internal and external respiration.	Internal and external respiration	1. Compare external respiration as it relates to other organisms with internal respiration.
227. The student will describe various ways in which CO_2 is carried in the plasma.	CO_2 exchange in plasma	1. Have students study charts or diagrams that show various mechanisms of CO_2 transport.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**228. The student will explain the mechanisms by which red blood cells facilitate CO_2 transport and O_2 delivery to the body tissues.	CO_2/O_2 exchange in blood	1. Have students study diagrams that show the mechanism of CO_2 and O_2 exchange.
*229. The student will describe several diseases of the respiratory system.	Diseases	1. Display advertisement of hazards of smoking. Contact the American Cancer Society. 2. Obtain photograph or samples of preserved tissues or slides showing pathological conditions of the respiratory systems.
XIII. THE TRANSPORT SYSTEMS		
A. THE BLOOD		
**230. The student will identify and compare erythrocytes from other vertebrates and describe various abnormal conditions.	Erythrocyte	1. Examine blood smears from various vertebrates. Prepare blood smear. Observe red and white cells. 2. Stain blood smear with Wright's stain. 3. Use the Tallquist method to determine the percent of hemoglobin in several samples of blood. (Colors on Tallquist scale determine the percent of hemoglobin).
**231. The student will identify the various types of leukocytes and give the function of each.	Leukocytes	1. Use prepared slides, films, videos, transparencies to replace fresh blood smears.
**232. The student will describe the basic components found in blood plasma.	Plasma	1. Obtain sealed tubes of heparinized blood and clotted blood. Have students compare each. Keep tubes refrigerated.
**233. The student will identify the basic blood types.	Blood types	1. Conduct blood typing simulation to show how typing works. Use animal blood.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
B. HEART		
*234. The student will describe the major functions of the heart and compare them to the functions in other classes of vetebrates.	Heart	1. Have students compare hearts of fish, amphibians, reptiles, and birds with mammals. 2. Examine a bisection or sagital section of sheep, calf or other large mammalian heart.
**235. The student will describe the path of blood through the heart, naming various chambers, valves, and connecting vessels.	Circulatory system	1. Dissect a calf heart to show valves, atria, ventricles, septua, etc. Also note coronary arteries and veins. 2. Compare bird, reptile, and amphibian heart to that of mammals. (obtain frog heart).
*236. The student will identify the three layers of the heart.	Heart	1. Dissect a calf heart. Examine layers around heart. 2. Compare tissues in other animals.
**237. The student will explain the complex mechanism of the heartbeat, and the contribution of the sinoatrial (S-A), and atrioventricular (A-V) nodes.	Cardiac cycle	1. Use stethoscope to listen to heart sounds. 2. Use a software package reference:
*238. The student will compare the influence of various chemical and physical factors on the rate of the heartbeat.	Factors affecting vascular system	1. Check pulse rates at different points along the major arteries.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
**239. The student will identify the various vessels that form the vascular system.	Vascular system	1. Examine circulation of blood in the tail of a fish. (Apply various chemicals as vasodiolators and vasoconstrictors). 1. Have student place a hand in ice water for two minutes. Observe color. Then have student place hand in extremely warm water. Note color. Explain.
240. The student will describe how the body maintains normal blood pressure.	Blood pressure	1. Microscope viewing of cross sections of arteries, veins, capillaries. 2. Take different readings on sphygmomanometer before, during, and after exercise Compare and explain results.
**241. The student will discuss the mechanics that control the distribution of blood throughout the vascular system.	Control of vascular system	1. Obtain videotape, film, or filmloop illustrating the mechanisms that control blood distribution.
**242. The student will describe the principal functions of the lymph system.	Lymphatic system	1. Have students use a triple-injected preserved animal to demonstrate lymphatic system.
**243. The student will name three lymphatic organs and explain their functions.	Lymphatic organs	1. Refer to activities in core.
**244. The student will compare active immunity to passive immunity and state an example of each.	Immunity	

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
XIV. THE REGULATORY SYSTEMS AND METABOLISM		
A. SKIN		
**245. The student will identify the anatomy of the skin and its accessory organs and compare it to mammals, birds, reptiles, and amphibians.	Skin	1. Make fingerprints and identify the various types. 2. Microscopic examination of various types of hair. 3. Examine electronmicrographs of hair. 4. Have students compare the hair on human skin to scales on reptiles and feathers on birds.
246. The student will list the disorders of the skin and its accessory organs.	Diseases and disorders of the skin	1. Examine a scar with a magnifying lens, note differences as compared with surrounding tissue.
B. BODY TEMPERATURE		
247. The student will describe the mechanism that regulates the temperature of the body.	Temperature regulation	1. Compare and contrast thermal regulation among birds, snakes, and other selected vertebrates.
C. KIDNEY		
**248. The student will discuss mechanisms and structures regulating excretion, including the kidney and all other excretory organs.	Excretory system	1. Trace the route of a cup of water from the time it is swallowed to the time it is excreted, either as urine, or as sweat. Do the same for nitrogenous waste from the breakdown of amino acids in the liver.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
XV. ENDOCRINE SYSTEM		
A. ENDOCRINE GLANDS		
**249. The student will identify the primary function of the major endocrine glands.	Role of endocrine glands	1. Examine the effect of thyroxins on metamorphosis of tadpoles. 2. Induce ovulation (egg production) in frogs. 3. Examine the effect of iodine on the metamorphosis of tadpoles.
250. The student will describe how hormones act as chemical regulators.	Hormone regulation	1. Suggest library research on the physiological effects of hormones on target cells, and on the mechanism of feedback control in hormone production, using examples. 2. Have students conduct library research on conditions that result from hormone imbalance.
XVI. REPRODUCTION		
A. REPRODUCTION AND DEVELOPMENT		
**251. The student will identify the structures of both the male and female reproductive systems.	Reproductive systems	1. Use audiovisual materials and models. 2. Ask a physician or nurse to come as a guest speaker.
**252. The student will explain the functions of the reproductive organs of both sexes.	Reproductive organs	1. Students write reports on research problems, diseases that are associated with reproductive organs.
B. PHYSIOLOGY		
**253. The student will list the changes that occur during the ovarian and menstrual cycles.	Cyclic changes	1. Have students compare the estrus cycles of various mammals and determine the frequency of births.

OBJECTIVE	CONCEPT	SUGGESTED ACTIVITIES
254. The student will describe the processes involved in the development of the fetus.	Fetal development	1. Display and discuss charts or models of developing fetus.
255. The student will describe the relationship of hormonal secretion with the implantation of an embryo and milk production.	Hormonal relationship	1. Have students study diagram that shows the relationship of hormones and pre- and post-natal respires.
**256. The student will compare monotremes marsupial mannals and placental mammals.	Marsupial	1. Compare the live births of all vertebrate animals. Discuss survival advantages of marsupials or placental offspring.

SKILLS [illegible]ECKLIST

BIOLOGY II	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB.† PAGE #
1. The student will briefly trace the development of the biological sciences from ancient cultures to the present.	*	*		
2. The student will state the names of some famous biologists and their contributions to the growth of biology.	*	*		
3. The student will discuss some major biological events of the past 50-100 years.	*	*		
4. The student will know some of the current events in the area of biology.	*	*		
5. The student will describe the differences between theories, hypotheses, and laws.	*	*		
6. The student will form hypotheses based on observations of biological phenomena.	*	*		
7. The student will design experiments to test hypotheses.	*	*		
8. The student will recognize the variables involved in a biological investigation and design experiments to test for variables.	*	*		
9. The student will demonstrate different methods of collecting data in an investigation.	*	*		

† This column is to be used for individual teacher's references.

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
10. The student will recognize that all variables may not be controlled in the design of an experiment.		*	*	
11. The student will interpret data in light of prestated hypotheses.	*	*		
12. The student will recognize data that supports or rejects stated hypotheses.	*	*		
13. The student will recognize that investigations may create new questions.	*	*		
14. The student will identify descriptive statistics that are used to evaluate numerical data.	*	*	*	
15. The student will demonstrate that statistics are not used to prove things but to support probabilities.	*	*	*	
16. The student will identify the difference between discrete and continuous variables.			*	
17. The student will identify the difference between random and biased samples.			*	
18. The student will design and carry out an experiment that requires a random sample.			*	

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
19. The student will recognize when samples are biased.			*	
20. The student will be able to demonstrate the ability to find the arithmetic mean, given a set of data.	*		*	
21. The student will be able to compute the variance.			*	
22. The student will be able to demonstrate the ability to find the standard deviation and to state what is meant by "normal" distributions.			*	
23. The student will use standard deviation in determining how much a set of data varies from the mean.			*	
24. Design and carry out an experiment which makes use of variance and standard deviation.			*	
25. The student will be able to define and state a null hypothesis.			*	
26. The student will be able to use the "t" test and "chi-square" tests.			*	

		REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
27.	The student will design and carry out an experiment which involves a test of significance.			*	
28.	The student will be able to describe ionic and covalent bonding.	*	*		
29.	The student will describe the unique structure of specific elements and compounds, such as: H_2O - water S-S sulfide CO_2 - carbon dioxide O_2 oxygen CH_4 - methane NH - ammonia	*	*		
30.	The student will be able to describe the characteristics of water.	*	*		
31.	The student will be able to determine the pH in living systems.	*	*		
32.	The student will recognize the basic chemicals of life such as CO_2, NH_3, and CH_4 and why each are unique.	*	*		
33.	The student will describe the uniqueness of the Carbon atom and the sp^3 orbital essential to all organisms.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
34. The student will recognize the basic organic functional groups of organisms and will be able to draw and define each.	*		*	
35. The student will recognize the four major types of compounds involved in metabolic reaction of all animals.	*			
36. The student will distinguish the various types of energy-storing molecules. These include sugars, starches, cellulose, fats, and chitin.	*		*	
37. The student will recognize various unique polysaccharides such as cellulose, glycogen, and chitin and identify their differences.	*			
38. The student will recognize the various kinds of fat (lipid) molecules and will be able to distinguish saturates, unsaturates, and polysaturate molecules.	*			
39. The student will recognize membrane structure and how phospholipids function.	*		*	
40. The student will define enzymes as biological catalysts.	*	*		

		REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
41.	The student will recognize that proteins are made up of peptides and may be able to define their major building blocks as amino acids.	*	*		
42.	The student will distinguish between a peptide bond and an ester bond.			*	
43.	The student will identify porphyrins structures such as hemoglobin and chlorophyll.			*	
44.	The student will identify basic structures of nucleic acids.	*	*		
45.	The student will compare and contrast between prokaryotic and eukaryotic cells.	*	*		
46.	The student will compare and contrast plant and animal cells.	*	*		
47.	The student will identify the structure and list functions of the cell membrane including exocytosis and endocytosis.	*	*		
48.	The student will list the structure and the function of organelles, the subcellular components of mobility, and the cytoskeleton.	*	*		

		REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
49.	The student will identify and compare the various stages of the cell cycle: mitosis, cytokenesis, interphase.	*	*		
50.	The student will be able to microscopically identify the different types of plant and animal tissues.	*	*		
51.	The student will be able to give the locations and functions of the different types of tissues.	*	*		
52.	The student will define and differentiate between the various kinds of tissues, e.g., epithelial, muscular, connective, and nervous and tell how they form organs.			*	
53.	The student will explain the characteristics of the three basic epithelial tissues and describe where they are found.	*	*		
54.	The student will identify the three types of muscular tissues (striated, smooth, and cardiac), and describe the general characteristics of each.	*	*		
55.	The student will list the major parts of a skeletal muscle both at the macroscopic and microscopic levels.			*	

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
56. The student will describe the concept of osmosis.	*	*		
57. The student will describe the process of active transport.	*	*		
58. The student will describe the evolution of metabolism at the cellular level. This will include fermentations, degradation of organic molecules, nitrogen fixation, and anaerobic photosynthesis.			*	
59. The student will be able to describe various stages of glycolysis and cellular respiration.			*	
60. The student will be able to identify the various stages of dark and light reactions of photosynthesis.	*	*		
61. The student will describe how chlorophyll and other pigments are used by plants to absorb various wave lengths of light.	*	*		
62. The student will demonstrate an understanding of the biochemistry of photosynthesis. This would include the role of oxygen, carbon dioxide, water, and the transformation of ATP and ADP.	*	*		
63. The student will identify ways in which pollution affects photosynthesis.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
64. The student will be able to differentiate between mitosis and meiosis.	*	*		
65. The student will be able to describe the stages of oögenesis and spermatogenesis.	*	*		
66. The student will be able to describe the advantages and disadvantages of sexual reproduction.	*	*		
67. The student will identify factors that affect an organism reproductive success. Such factors would include age of reproduction, litter size, number of litters per lifetime, interval of birth and reproductive cost.	*	*		
68. The student will describe reproductive strategies.	*	*		
69. The student will be able to differentiate between nonspecific defense mechanisms and specific defense mechanisms in the immune system.			*	
70. The student will be able to explain the importance of the development of an immune system in the vertebrates.			*	
71. The student will be able to identify the types of immunity.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
72. The student will be able to identify the role of antibiotics, interferons, chemical inhibitors in plants, and the complement system.			*	
73. The student will be able to explain the role of the cells involved as specific defense mechanisms.			*	
74. The student will be able to explain the role of plasma proteins.			*	
75. The student will be able to explain why the lymphatic system is the center of immunity.	*	*		
76. The student will be able to explain the immune response in terms of antigen-antibody reactions.	*	*		
77. The student will be able to explain the body's allergic response to environmental factors.			*	
78. The student will be able to describe the therapeutic alternatives utilized to supplement a weakened immune system.			*	
79. The student will be able to relate transplatation, tolerance, and autoimmunity to the immune system.			*	
80. The student will explain the significance of Mendel's laws of heredity.	*	*		

		REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
81.	The student will explain the laws of probability.	*	*		
82.	The student will list and define several examples of inheritance patterns, such as sex-linked, sex-influenced, sex-limited.	*	*		
83.	The student will be able to demonstrate an understanding of the terms: chromosome, gene, allele, homogygous, heterogygous	*	*		
84.	The student will explain the results of gene interactions.	*	*		
85.	The student will relate gene action to cause of several human genetic defects, ex. PKU, Down's, Sickle cell, Cystic Fibrosis, Tay-Sachs.	*	*		
86.	The student will describe the steps of DNA replication and its involvement in translation and transcription.	*	*		
87.	The student will list causes of mutations.	*	*		
88.	The student will be able to explain recombinant DNA, DNA cloning, hybridization, and DNA sequencing.			*	

		REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
89.	The student will be able to explain the following terms: Split genes (intros-exons) Oncogene activity Gene mapping from cross-over data RNA processing Continuous-discontinuous DNA synthesis Karyotyping Chromosome-gene anomalies Point mutations Frame shift mutations Base analogs Euploidy Aneuploidy Retroviruses Plasmids Tests for Genetic Anomalies 1. Alpha-fetoprotein test 2. Amniocentesis 3. Ultrasonography 4. Chorion biopsy			*	
90.	The student will state various theories concerning the origin of life.			*	
91.	The student will discuss the development of evolutionary theory.			*	
92.	The student will list evidence supporting evolution and discuss problems with early concepts.			*	

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
93. The student will explain how natural selection affects evolution.			*	
94. The student will explain the significance of the Hardy-Weinberg principle in genetics.			*	
95. The student will describe factors influencing allelic frequencies.			*	
96. The student will describe the different patterns of evolution (allopatry, sympatry, adaptive radiation, gradualism, punctuated equilibrium).			*	
97. The student will be able to discuss the history of taxonomy and how the modern system of taxonomy relates to the theory of organic evolution.			*	
98. The student will be able to develop a dichotomous key for a given group of organisms.		*	*	
99. The student will be able to name the seven major levels of classification.	*	*		
100. The student will discuss the five-kingdom system.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
101. The student will be able to distinguish between the three majcr kingdoms of microorganisms (Monera, Protista, Fungi). Discuss the five-kingdom system.	*	*		
102. The student will explain the ecological relationship of each kingdom to man and other organisms.	*	*		
103. The student will perform laboratory activities involving the growth and identification of organisms from the three kingdoms of microorganisms.			*	
104. The student will describe the special characteristics of viruses that set them apart in the living world.	*	*		
105. The student will discuss the ecological relationship of viruses to man and other organisms.	*	*		
106. The student will distinguish between the vascular and non-vascular plant groups.	*	*		
107. The student will describe the diversity of structure in the taxonomy of plants.	*	*		
108. The student will discuss the life cycle of non-vascular plants; liverworts, moss, ferns.	*	*		
109. The student will describe alternation of generations in plant groups.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
110. The student will identify and describe the structure and function of vascular plants including leaves, stems, roots, and adaptations to climatic change.	*	*		
111. The student will describe sexual reproduction in flowering plants.	*	*		
112. The student will discuss the diversity of structure in seeds and fruit.	*	*		
113. The student will describe ways in which seeds are dispersed in the environment.	*	*		
114. The student will describe types of asexual reproduction in flowering plants.	*	*		
115. The student will describe plant responses to environment stimuli.	*	*		
116. The student will describe the role of plant hormones in the regulation of growth and response to environmental stimuli.	*	*		
117. The student will be able to discuss photoperiodicity in plants and how it affects growth.	*	*		
118. The student will be able to describe the morphological and physiological characteristics of radially symmetrical animals: cnidaria and ctenophora.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
119. The student will be able to describe the morphological and physiological characteristics of bilaterally symmetrical aceolomates, pseudocoelomates, and coelomates.	*	*		
120. The student will be able to draw a distinction between invertebrate and vertebrate animal groups.	*	*		
121. The student will be able to describe the morphological and physiological differences of the following phyla: Porifera, cnidaria, plathyhelminthes, nemotada, annelida, mollusca, arthropoda, echinodermata, chordata.	*	*		
122. The student will be able to recognize the characteristic morphological and histological differences among the classes of vertebrates. (Agnatha, Chrondrichthyes, Osteichthyes, Amphibia, Reptilia, Aves, Mammalia)			*	
123. The student will be able to describe homeostasis in vertebrates, for example: excretion, respiration, temperature regulation.	*			
124. The student will be able to compare the physiology of transport systems among the classes of vertebrates.	*			

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
125. The student will be able to compare the physiology of the muscle system among the classes of vertebrates.	*	*		
126. The student will be able to compare the physiology of the nervous system among the classes of vertebrates.	*	*		
127. The student will be able to compare the physiology of the digestive system among the classes of vertebrates.	*	*		
128. The student will be able to make comparisons in the reproduction and development of vertebrate animals.	*	*		
129. The student will be able to compare the physiology of the excretory system among the classes of vertebrates.	*	*		
130. The student will be able to compare the physiology of the endocrine system among the classes of vertebrates.	*	*		
131. The student will be able to make comparisons in the development of vertebrate animals.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
132. The student will be able to identify some common terms and influential people in the area of animal behavior. (Ethology, motivation, pheromones, drives, Lorenz, Pavlov, Thorndike, etc.)	*	*		
133. The student will be able to compare and contrast innate and learned behaviors in animals.			*	
134. The student will distinguish between different types of innate behaviors in animals			*	
135. The student will distinguish between different types of learned behaviors in animals (habituation, trial and error, insight, conditioning, imprinting).			*	
136. The student will discuss the role of hormones in animal behavior. (Biorhythms)	*	*		
137. The student will be able to define environment as a combination of external conditions that influence the life of an individual, organism, or population.	*	*		
138. The student will be able to recognize that the definition of ecology is the interrelationship of organisms to their environment.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
139. The student will demonstrate an understanding of the relationship between environment and ecology by listing and discussing external conditions connecting their environment.	*	*		
140. The student will be able to describe the levels of ecological organization of: a. biosphere b. biome c. ecosystem d. community e. population f. organism	*	*		
141. The student will describe characteristics of ecological succession.	*	*		
142. The student will list and describe characteristics of Earth's major biomes.	*	*		
143. The student will be able to define biosphere as the portion of the earth and its atmosphere capable of supporting life.	*	*		
144. The student will be able to list the major biomes.	*	*		
145. The student will be able to define an ecosystem as a natural community of organisms interacting with one another and with their environment.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
146. The student will be able to define and identify a community as a group of populations occupying a particular habitat or area.	*	*		
147. The student will explain energy pathways through living systems. (Food chains, Food webs, Energy pyramids, etc.) Carbon budget and energy flow.	*	*		
148. The student will describe biogeochemical cycles and explain their importance to living systems. (water, N_2, C, S, P)			*	
149. The student will be able to distinguish the difference between the terms "habitat" and "niche."	*	*		
150. The student will be able to recognize and identify various kinds of habitats and niches.	*	*		
151. The student will describe the dynamics of a community including such factors as coevolution, predator-prey relationships, and symbiosis.	*	*		
152. The student will be able to define population as a group of organisms of the same species.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
153. The student will describe the impact of biotic and abiotic factors on populations.	*	*		
154. The student will describe the concept of carrying capacity.	*	*		
155. The student will describe stages of growth of a population.	*	*	*	
156. The student will demonstrate an understanding of the early ideas of population growth.			*	
157. The student will be able to list several principles pertaining to the organization of population levels. These would include density, natality, mortality, age distribution, and fecundity.			*	
158. The student will be able to draw and interpret an idealized population growth curve, a logarithm curve, exponential growth, and "plateau effect."			*	
159. The student will be able to describe geometric population growth and contrast it with arithmetic growth.			*	
160. The student will be able to explain how to estimate a population growth by using extrapolation or prediction.			*	

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
161. The student will be able to demonstrate that the carrying capacity is determined by the availability of materials and conditions necessary for maintaining a particular kind of organism and that the earth's carrying capacity is limited for all species, including man.			*	
162. The student will recognize various types of feeding strategies and their effects on populations, e.g., specialized feeder, opportunistic, etc.			*	
163. The student will describe how mortality, fecundity (number of reproducing females) and other demographic factors affect population growth.			*	
164. The student will be able to describe human cultural evolution and its impact on human populations. This should include agriculture.			*	
165. The student will discuss biological factors affecting population such as nutrition, disease, famine, changes in birth or death rate.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
166. The student will be able to recognize why the world's human population increases despite a simultaneous decrease in the birth rate.	*	*		
167. The student will be able to recognize the effect increasing population has on the social structure of a civilization.			*	
168. The student will be able to recognize the cultural factors affecting population levels.			*	
169. The student will be able to discuss the effect of urbanization on population levels.			*	
170. The student will be able to recognize that all organisms have the capability of reproducing beyond the availability of food resources.			*	
171. The student will identify renewable and nonrenewable resources and give examples of each.		*		
172. The student will be able to identify energy sources available to humans, their role in society, and their levels of efficiency and conservation.			*	

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
173. The student will be able to recognize natural and man-made pollution and their impact on man and his environment.	*	*		
174. The student will be able to describe various types of man-made pollution over the past thousand years. These include sources of air pollution, water pollution, and his environment.	*	*		
175. The student will describe the history of vertebrate study and identify various fields of work.			*	
176. The student will describe the various levels of structural organization within the vertebrate body. This would include chemical, cellular, tissue, organ, and system level.	*	*		
177. The student will recognize basic directional terms used in anatomy and physiology.	*	*		
178. The student will identify the various body cavities.	*	*		
179. The student will list the ten body systems.	*	*		
180. The student will define and differentiate between the various kinds of tissues such as: epithelial, muscular, connective, nervous.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
181. The student will explain the characteristics of the three basic epithelial tissues and describe where they are found.			*	
182. The student will be able to list four functions of the skeletal system and compare these functions to each class of vertebrates.	*	*		
183. The student will be able to identify structural parts of a typical long bone found in all vertebrates.	*	*		
184. The student will be able to distinguish between the axial division and the appendicular division of the skeleton and recognize the bones in each.	*	*		
185. The student will be able to identify the six types of joints and give examples of each.	*	*		
186. The student will be able to distinguish between a ligament and a tendon.	*	*		
187. The student will be able to describe the three muscle types.	*	*		
188. The student will be able to compare the differences in the histology of the three muscle types.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
189. The student will be able to describe the events that take place during a muscle twitch.			*	
190. The student will be able to explain the mechanism of muscle fiber contraction and how energy is supplied.			*	
191. The student will define origin and insertion and locate skeletal muscles in the vertebrate body.	*	*		
192. The student will explain the function of antagonistic muscle groups.	*	*		
193. The student will identify functions of the skeletal muscles within the classes of vertebrates and compare their function.	*	*		
194. The student will describe the general structure of a neuron.	*	*		
195. The student will understand the way in which structure and function are used to classify different kinds of neurons.	*	*		
196. The student will summarize the activities that lead to the transmission of a nerve impulse.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
197. The student will name two major divisions of the nervous system.	*	*		
198. The student will describe the structure and function of the spinal cord and compare spinal cords of various classes of vertebrates.			*	
199. The student will identify parts of vertebrate brain and their function and compare the anatomy of various classes of vertebrates.	*	*		
200. The student will identify the function of the motor, sensory, and associative areas of the cerebral cortex.	*	*		
201. The student will name two major parts of the peripheral nervous system.	*	*		
202. The student will identify the 12 pairs of cranial nerves.	*	*		
203. Describe how depressant and stimulant drugs work on the CNS.		*	*	
204. The student will identify the embryonic eye and describe the development and function of each part.		*	*	
205. The student will describe how the light-sensitive cells, the rods and cones function.		*	*	

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
206. The student will summarize the way in which the light waves passing through the various structures of the eye are converted into nerve impulse.			*	
207. The student will define the terms refraction, convergence, accommodation and how they relate to vision.			*	
208. The student will use from comparative evidence from comparative anatomy and developmental biology to explain the structure and function of the different divisions of the ear and how they developed.			*	
209. The student will trace the path of sound waves through the organ of the ear to the brain.			*	
210. The student will explain equilibrium and describe how the structures function in the various classes of vertebrates.			*	
211. The student will understand the importance of vitamins and minerals in terms of their primary sources, functions, and deficiency disorders.	*	*		
212. The student will describe the function of enzymes in the vertebrate body.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
213. The student will compare the anatomy of the mouth, pharynx, esophagus among vertebrates.			*	
214. The student will compare the development of teeth among vertebrates.			*	
215. The student will describe location of salivary glands and the function of their secretion.	*	*		
216. The student will identify different tastebud locations and how they differ in other classes of vertebrates.	*	*		
217. The student will describe anatomy and the histology of the stomach and compare it to various mammals.			*	
218. The student will identify the components and the function of gastric juice and explain the mechanism by which gastric secretion is regulated.			*	
219. The student will describe the anatomy of the peritoneum, small intestine, and large intestine.	*		*	
220. The student will describe the composition and function of each of the intestinal secretions.			*	

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
221. The student will describe the mechanisms that regulate enzyme digestive secretions.	*	*		
222. The student will compare structures of the nose, nasal cavities, and pharynx, trachea, bronchi, and bronchioles and lungs among the classes of vertebrates.			*	
223. The student will describe the functions of the larynx and the pleural membrane.	*	*		
224. The student will explain the mechan* of air movements during inspiration and expiration in each class of vertebrates.	*	*		
225. The student will explain the function of the gas laws in respiration. (Dalton & Boyle)			*	
226. The student will define the differences between internal and external respiration.	*	*		
227. The student will describe three ways in which CO_2 is carried in the plasma.	*	*		
228. The student will explain the mechanisms by which red blood cells facilitate CO_2 transport and O_2 delivery to the body tissues.	*	*		
229. The student will describe several diseases of the respiratory system.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
230. The student will identify and compare erythrocytes from other vertebrates and describe various abnormal conditions.	*	*	*	
231. The student will identify the various types of leukocytes and the function of each.	*	*		
232. The student will describe the basic components found in blood plasma.	*	*		
233. The student will distinguish between 4 basic blood types and identify blood groups.	*	*		
234. The student will describe the major functions of the heart and compare to other classes of vertebrates.	*	*		
235. The student will describe the path of blood through the heart, naming various chambers, valves, and connecting vessels.	*	*		
236. The student will identify the three layers of the heart.	*	*		
237. The student will explain the cardiac cycle and the mechanism of the A-V and S-A nodes.	*	*		
238. The student will compare influence of various chemical and physical factors on the rate of the heartbeat.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
239. The student will identify the various vessels that form the vascular system.	*	*		
240. The student will describe how the body maintains normal blood pressure.			*	
241. The student will discuss the mechanics that control the distribution of blood throughout the vascular system.	*	*		
242. The student will describe the principle functions of the lymph system.	*	*		
243. The student will name three lymphatic organs and explain their functions.	*	*		
244. The student will compare active immunity to passive immunity and state an example of each.	*	*		
245. The student will identify the anatomy of the skin and its accessory organs and compare it to mammals, birds, reptiles, and amphibians.	*	*		
246. The student will list the disorders of the skin and its accessory organs.			*	
247. The student will describe the mechanism that regulates the temperature of the body.			*	
248. The student will discuss mechanisms and structures regulating excretion, including the kidney and all other excretory organs.	*	*		

	REVIEW	MASTERED	INTRODUCED	TEXT OR LAB. PAGE #
249. The student will identify the primary function of the major endocrine glands.	*	*		
250. The student will describe how hormones act as chemical regulators.	*	*		
251. The student will identify the structure of both the male and the female reproductive systems.	*	*		
252. The student will explain the functions of the reproductive organs of both sexes.	*	*		
253. The student will list the changes that occur during the ovarian and menstrual cycles.	*	*		
254. The student will describe the processes involved in the development of the fetus.			*	
255. The student will show the relationship of hormonal secretion with the implantation of an embryo and milk production.			*	
256. The student will compare marsupial and placental monotremes.	*	*		

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Scientific American Filmstrip, Scientific American, Inc., 415 Madison AVenue, New York, N. Y. 10017.

Visual Science, Box 599, Suffern, N. Y. 10901. Films and filmstrips.

Educational Images, Box 3456, West Side Station, Elmira, N. Y. 14905. Telephone (607) 732-3510. Slides, filmstrips, and computer hardware.

Time-Life Films, Paramus, N. J.

Popular Science Audio-Visuals, New York

FILM RESOURCES

Modern Talking Picture Services, 45 Rockefeller Plaza, New York, N. Y. 10020. Telephone (212) 765-3100.

College Films, College Film Center, 332 S. Michigan Avenue, Chicago, IL 60604. Telephone (312) 922-6621.

Educator's Guide to Free Audio and Video Materials, Educators Progress Service, Inc., Fandolph, WI 53956. Telephone (414) 326-3126.

Shell Oil Film Library, 1433 Sadlier Circle W. Drive, Indianapolis, Indiana 46239.

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King Features, Inc., 235 E. 45th Street, New York, NY 10017. Distributors of selected NOVA episodes. Telephone (212) 682-5600.

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AUDIO VISUAL AIDS SUPPLIERS

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EVALUATION TECHNIQUES

Students in secondary school are developing into young adults, and are at different levels of development. Differences in physical and mental growth, opportunities, experience, and age affect a student's performance in the classroom. Evaluation should always take these differences into account. As with learning styles, evaluation should address the student's testing ability. In science, a tremendous amount of emphasis is placed on knowledge. This level of knowledge is aimed at promoting scientific literacy. Few students, however, will become scientists or engineers, yet many will work in technical fields, will be required to interpret scientific information, and will need to understand basic biological and physical principles.

Evaluation of student should be based on more than a score or a single observation. Evaluations should include many different methods, each addressing the various learning and testing styles of students, and each aimed at assessing all taxonomic levels. Evaluation is the first sign of what is expected of the students by the teacher, therefore initial evaluations should set the standard for the remainder of the course. The evaluation should reflect the performance objectives. Methods for evaluating pupil achievement and progress are an integral part of the instructional program. Evaluation techniques must reflect (1) the objectives to be reached, and (2) the activities employed to reach those objectives. If the objectives are stated clearly, the methods of evaluation are indicated within the objective. In this guide, the objectives are stated in behavioral terms and suggested activities are listed. The process skills are not identified because the skills will vary according to the manner in which the objective is taught. For every objective, it is clear what the student is expected to be able to do after successful completion of a learning activity. The successful attainment of an objective can be demonstrated by the student's being able to do specific things which can be observed.

One method of evaluation includes problem solving. Students should be required to gather data or information on which to base their response. These data or information should be presented in an appropriate manner for interpretation. Students may be evaluated on their interpretation and presentation.

Evaluation of problem-solving abilities involves more than assessing accuracy of information; it requires careful review of the explanation used for arriving at conclusions. The evaluation of criterion referenced tests, normative tests, essays, laboratory reports, activity reports, or explanations involves assessing the technical information used to explain the scientific principles, the analytical procedures, and the precision and quality of the language used in presenting the information.

Another method of evaluation includes paper and pencil tests. Students may be asked to analyze or interpret data. These interpretations may be evaluated as to how their responses were derived. Pencil and paper tests may be used to identify concepts, words, and ideas associated with objectives. Although essay questions are most effective for students who can write well, essay tests should be included in the testing experience of all students.

Performance and participation coupled with observed behavioral changes may also be an excellent method of evaluation. This type of evaluation may be used when simulation exercises are used. A simulation exercise in Biology II might include a local problem that involves environmental issues. Students are assigned "parts" or "roles." These roles may have alternative views about how the environmental problem might be solved. The students are asked to research their views and present their ideas and information before the class, much like a hearing. Following the "mock" hearing, the students may be tested with a paper and pencil test. Such activities promote the use of process skills and tend to move the learner into the center of learning, rather than to keep the teacher at the center of the instruction. Therefore, evaluation should consist of more than just paper and pencil tests on recall of factual knowledge. A variety of evaluative activities should be used.

The use of laboratories in Biology II may include field exercises: field trips, observations made outside of school, and special opportunities students might have to find issues that affect the environment. Students should be assessed as to their ability to observe outside the classroom environment.

Some norm-referenced instruments are available for teachers. It should be realized that often items may reflect historical issues to which many students have never been exposed. In addition, normative testing may also reflect regional or local issues that are unknown in this region of the nation.

PROGRAM EFFECTIVENESS

Teachers should be continually evaluating their own courses. The student performance level measured by normative reference tests are always good comparative devices. However, other methods should be used to evaluate a teacher's program. Consider these questions:

Do you apply up-to-date technology or laboratory apparatus when teaching?

Do you provide and encourage independent investigations?

Do you rely heavily on journal articles?

Do you encourage students to continue learning about science regardless of sex or role or performance?
What proportion of the students are enrolled in science classes at each grade level?

What is the proportion of students who take advanced science courses?

How much interdisciplinary teaching and cooperation is going on in your school?

Evaluation is a key in documenting success or need for improvement. Collecting test data, observations, and analyzing of such data should encourage a teacher to use science to evaluate their own progress.

APPENDIX

The
College
Board

SAMPLE LABORATORY EXERCISES

A. Amino Acid Chromatography

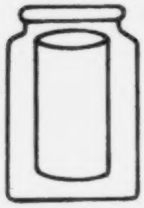
B. Dorsey, York Community High School, Elmhurst, IL

You will first make a chromatograph of the 18-20 amino acids that you will use as a standard. Then you will be given an unknown which you will run on a separate chromatograph and, using the standard, will identify your unknown.

First day - Prepare the standards.
You will work in groups of 3 or 4; each group will standardize 6 or 7 amino acids.

Procedure:

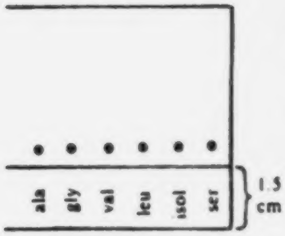
Cut a piece of chromatograph paper to a width that, when rolled into a cylinder, will fit upright in one of the large jars.



BE CAREFUL NOT TO TOUCH THE PAPER.

On one edge of the paper mark a series of six dots with a lead pencil. These dots should be approximately 1.5 cm from the edge and an equal distance from each other.

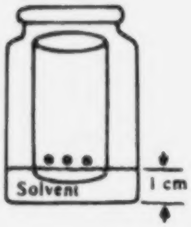
Remember that you are going to roll the paper into a cylinder, so the dots can be on only the exposed part.



Using a lead pencil, label the dots with the names of the amino acids that your group is assigned to study.

Carefully apply the amino acids to the specified dot by taking a small amount in the capillary tube and touching it to the appropriate pencil dot.

Allow this to dry approximately 2 min and then apply a second amount to the same spot. Repeat this exactly 6 times. In order to finish, you will have to be working on all 6 amino acids simultaneously.



Pour about 1 cm of solvent (10 parts formic acid, 70 parts isopropanol, 20 parts water) into the jar. Do not get it on the sides.

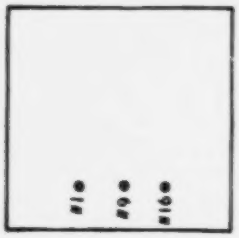
When you have finished, roll the paper into the cylinder and paper clip it top and bottom. Be sure the edges are separated.

Stand the cylinder in the jar and carefully close it with a lid or parafilm.

At the end of a given period of time, I remove the papers, allow them to dry, take them to the chemistry lab and, using the vent-hoods, spray them with ninhydrin. This causes the amino acids to appear.

Second day - Amino acid unknown

Working in groups of 3, each of you will be given a different unknown. You will make a chromatograph of your material. Follow the same procedure. Cut the paper.



Mark your dot.

Label it.

Apply your material.

Make the cylinder.

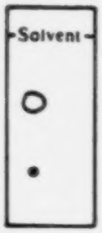
Put it in the solvent in the jar.

When you have finished, you will work on yesterday's standards as follows:
Obtain your chromatograph.
Carefully circle each amino acid with a lead pencil.
Figure the Rf (rate of flow) for each amino acid.

$$Rf = \frac{\text{distance the amino acid moved}}{\text{distance the solvent moved}}$$

When each group has finished, the class will have a complete standard. All of the amino acids will be done.

Third day - Obtain your chromatograph.



Cut the paper into strips so each person has one unknown amino acid.

Circle your amino acid with a lead pencil.

Figure the Rf.

By comparison with the standards, decide which amino acid(s) were in your unknown.

Note: On your lab report you will be required to reproduce the standard chromatographs and to attach your actual unknown graph.

B. Plant Hormones - The Scientific Method

Adapted by L. Earll, Garrison Forest School, from Laboratory Manual for General Biology by Sturdivant, Royer, and Kerschner

Materials and Experimental Procedures

1. Two potato plants are grown for the same length of time. One plant is grown in the dark and one in the light.
2. Two geranium plants are grown, with one plant receiving a unilateral source of light and the control receiving light from all directions.
3. Rye seeds are grown in jars of water. The control jar has light available from all directions. The experimental jar is blackened except for one strip so that the roots receive light from one direction only.
4. Corn is grown in boxes constructed with 2 glass sides. One box, the control, is grown with the box bottom horizontal. The experimental corn is grown with the box tilted at a 45° angle.
5. Two boxes of the same type as those used in 4 are used for this experiment. One box is watered throughout. The other box is watered well on one side but little on the other side.

The Scientific Method

The experiments you will observe today are all concerned with the effect of certain environmental factors (light, gravity, and water) on the direction of growth of stems and roots of certain plants. In each experiment one plant has been exposed to a slightly different environment from that of the "control."

What is a control?

All the experiments deal with the effect of environmental conditions on the rate of stem and root growth. The growth differences that we will explore are due primarily to unequal rates of cell elongation, controlled by a hormone called auxin. Plant growth is governed by hormones just as is animal growth.

There are several important facts to keep in mind as you observe.

1. Auxin is an actual substance.
2. A hormone is a chemical messenger.
3. In stems, the greater the concentration of auxin, the greater the rate of cell elongation.
4. The concentrations of auxin, which stimulate cell elongation in stems, inhibit cell elongation in roots.

Experiment 1

a. Description
b. What do you observe concerning the effect of light on stem elongation?
c. Is light necessary for all phases of growth?
d. How does light affect the distribution of auxin in a stem?

Experiment 2

a. Description
b. Is there any correlation between this experiment and the previous one?
c. How does the intensity of light affect the reaction of auxin in stems? What evidence?
d. Does a stem bend toward light because it needs light for growth?
e. What effect would light probably have on stems grown in water?

Experiment 3

a. Description
b. Why do we put the roots in a water solution?
c. Does light affect root growth in the same way that it does stem growth?
d. How does light, coming from one direction only, affect the distribution of auxin in roots?
e. In what direction would roots grow in the absence of light? What is the reason for your answer?

Experiment 4

a. Description
b. How do the roots tend to grow (that is, what direction) after the box has been tilted? What about the stems?
c. Explain these growth curvatures on the basis of the distribution of auxin as influenced by gravity. How does gravity affect the distribution of auxin in a plant?

Experiment 5

a. Description
b. Why do roots grow downward?
c. Does the distribution of water affect the direction of root growth?
d. Does the distribution of water affect the amount of root growth?
e. Does moisture in the soil influence the distribution of auxin in the roots? Give evidence for your answer.

C. Enzymes

N. Peterson, Oak Park and River Forest High School, Oak Park, IL

Purpose: To introduce the student to the nature and scope of the biochemical activity indicative of metabolic reactions within all cells. The liver contains enzyme systems, one of which is catalase, the enzyme studied in this experiment.

Materials

Disposable syringe
Ring stand
China marker or other marker
3% H_2O_2
Ice
Culture dish

Buret clamp
50-ml buret, cap or
 rubber stopper
Tubing
50-ml Erlenmeyer flask
 (or 50-ml test tube)
1-Hole rubber stopper
3" Glass tubing, #4
Beaker, 1-liter

Thymol crystals
Beakers
Funnel
Filter paper
Distilled water
Buffer solutions
 (pH of 2,5,7,8,12)
Liver
Wood splints

Thermometer-°C
Mortar, pestle
Cheesecloth
Sand
Scalpel
Erlenmeyer flask
Narrow-tip pipet

Apparatus and Procedure

1. Fill the 1-liter beaker three-fourths full with tap water. Fill the 50-ml buret to the top with water. Check to see that the stopcock is closed. Place the cap or stopper or your thumb over the top of the opening of the buret; invert it and submerge in the water trough. Clamp the buret securely to the ring stand. Place a paper towel between the clamp and buret to avoid breakage.
2. Open the stopcock and allow the water level to drop to an easily read mark. It helps if the level is marked with a china marker.
3. If it is not provided, cut glass tubing to approximately 3 in and insert in a twisting motion into the rubber stopper until a 2-in tube of glass is below the stopper.
4. Attach the tubing securely to the outside portion of the glass tubing and set this aside.

Liver Extract Preparation

1. Cut 3 or 4 pieces of frozen liver, each about 1 cm^3.
2. Place in a mortar with a little distilled water and sand. Grind.
3. Filter through cheesecloth into an Erlenmeyer. This is your initial stock solution and may be preserved in the refrigerator for a few days. A crystal of thymol will help.
4. It may be necessary to filter a second time with paper.

Experiment Under Standard Conditions

1. Place exactly 10 ml of stock liver extract solution into the 50-ml Erlenmeyer flask or tube. If you use a tube, rest it in a beaker. Place the one-holed stopper with the glass fitting securely on the top of the flask and insert the opposite end of the tubing into the open end of the buret that is submerged in the water. You may have to shift the buret to position the tubing correctly. Some water will go into the tubing. Check to make sure that all connections of tubing are tight.
2. Obtain a disposable syringe and draw 1 ml of H_2O_2 into the syringe.
3. Insert the syringe needle into the tubing rapidly at the junction of the tubing and the glass fitting. Aim directly down onto the substrate and rapidly push the plunger down the syringe and quickly remove from the tubing.
4. Now shake the Erlenmeyer flask with a slow and constant rotary motion.

5. To determine the rate of this reaction, watch the amount of water in ml that is displaced into the beaker. Observe the bubbles of gas over a period of 3 min. Begin this 3-min timing the instant you introduce the H_2O_2.
6. This step is optional; you may have done it or remember it from your beginning biology class. Slowly turn the buret valve releasing the accumulated gas into an inverted test tube. (Do not permit the water to enter the buret valve.) Quickly insert a glowing splint into the test tube and watch.
7. Record the ml of H_2O_2 displaced in 3 min at 100% enzyme stock solution. If you repeat the experiment, take an average.

Temperature Variable

Extra Materials:

Incubators set at 20°C, 37°C, 50°C; refrigerator, culture dish, ice, hot water, thermometer.

1. The experiment above will be repeated at these temperatures.
2. Collect 10 ml of enzyme in a test tube or Erlenmeyer as described before.
3. Fill the syringe with 1 ml H_2O_2 as before.
4. Leave both in the appropriate incubator for about 30 min for temperature equilibration.
5. Meanwhile, establish a water bath of the required temperature by mixing hot and cold water. Pour this into the beaker.
6. Repeat the experiment.
7. All three can be conducted at once.

pH Variable

Extra Materials:

Buffer of 2, 5, 7, 9, pH paper, distilled water.

1. Solutions of liver extract must now be prepared with the following buffered pH solutions: 2, 5, 7, 9.
2. Simply grind the liver in these solutions and proceed as before.

Enzyme Variable

Repeat the experiment under standard conditions with 20%, 50%, and 70% dilutions of the stock solution.

D. Phosphorylase

N. Peterson, Oak Park and River Forest High School, Oak Park, IL

Materials

0.2% starch
Potato
.01-N NaF
7 tubes
.01-M glucose
.01-M glucose 1-phosphate
.02-M KH$_2$O$_4$
Iodine
Spot plate
Cheesecloth
Knife
Blender
Centrifuge

Procedure

1. Prepare the following test tubes (or a spot plate can be used):
    1. 3 ml of 0.01-M glucose
    2. 3 ml of 0.01-M glucose-1-phosphate
    3. 3 ml of 0.01-M glucose-1-phosphate
    4. 3 ml of 0.01-M glucose-1-phosphate
    5. 3 ml of 0.01-M glucose-1-phosphate & 1 ml of 0.2-M KH_2PO_4
    6. 3 ml of 0.2% starch & 1 ml of 0.2-M KH_2PO_4
    7. 3 ml of 0.2% soluble starch & 1 ml of 0.2-M KH_2PO_4
2. Add a very small drop of the 0.2% starch solution to tubes 1, 2, 4, and 5 to act as primer. There should be so little starch present in these tubes that the iodine test is negative or very nearly negative. Check it.
3. With a paring knife, peel a small potato and cut it into small cubes. Place these in a Waring blender, add 40 ml of 0.01 -N NaF, and grind for 30 sec. We use it here to inhibit potato phosphatase, which would otherwise hydrolyze glucose-1-phosphate to glucose and phosphoric acid.
4. Filter the homogenate through a double layer of cheese cloth into a beaker. Squeeze out as much of the liquid as you can.
5. Centrifuge the suspension for 3 min, then decant and keep the supernatant. This is the enzyme. Test this extract to see that it is negative to iodine.
6. Transfer approximately 10 ml of the extract to a test tube, and heat for 5 min in a boiling water bath.
7. Now add 3 ml of the enzyme preparation to tubes 1, 2, 3, 5, and 6; and 3 ml of the boiled enzyme preparation to tubes 4 and 7. Use the enzyme as soon as you have finished preparing it, since it deteriorates rapidly. Fresh enzyme must be prepared.
8. Test each of these mixtures at once and at 3-min intervals thereafter with iodine. The reaction should be completed within about 30 min.

Analysis

What was the purpose of each component in the mixtures you prepared? What was the point of each mixture? What might have happened had you left the fluoride out of the enzyme preparation? If you have time, try doing that. How do you account for the fact that though the number of polysaccharide molecules has not changed, you now obtain a positive test with iodine whereas initially you didn't?

E. Gradient Agar Plates

N. Peterson, Oak Park and River Forest High School

You will observe 6 dishes of agar (A through E) such as those you used to prepare in beginning biology. However, each dish is a unique experiment using 2 slanted layers. Two slanted layers thus establish a "gradient" of some chemical substance.

Here is the general technique used in preparing all 6.

1. Sterile, nutrient agar-primary potassium phosphate ($\underline{M}$ KH_2PO_4) has been poured into a sterile petri dish using sterile technique. This creates a slightly acid pH.
2. Before solidification, one edge of the dish was placed on a pencil or other such edge. Thus the agar solidified at a slant.
3. When solid, the bottom was marked with an arrow in the direction of the thickest part of the bottom layer, called, hereafter the gradient.
4. The dish was "uprighted." Secondary potassium phosphate ($\underline{M}$ K_2HPO_4) was poured on top. This creates a slightly basic pH. This is also allowed to solidify.

Here is what has been done to each dish.

A. 1 ml KH_2PO_4 in the bottom layer.
1 ml K_2HPO_4 in the top layer.
A strip of filter paper that had been soaked in an indicator, bromthymol blue, has been laid across the top.
B. As in A, but the plate has been inoculated with a "zigzag" of *Serratia marcescens*.
C. As in both A and B, but *Escherichia coli* was added to both layers. A strip of filter paper soaked in 25 mg streptomycin has been laid along the surface.
D. This is a repeat of C but has been done with discs to verify the effectiveness of the streptomycin.
E. As in C, but penicillin has been used.
F. As in E, but with discs.

For dishes G and H, *neither* phosphate was used.

G. Streptomycin was added to the bottom layer. *E. coli* was added to the top layer. A strip of zinc chloride soaked filter paper was laid on top.
H. As in G, but penicillin was used rather than streptomycin.

After observing all, choose one. Hypothesize the results. Then design an experiment to test these results. You may choose more than one or combine the results of several.

F. Detecting Bacterial Pollution in Water

T. Richardson, University School of Milwaukee, WI (Adapted from a lab at Marquette University)

In densely populated areas, water pollution by sewage is an ever-present hazard. Several serious diseases can be traced to polluted drinking water, among them typhoid fever and a group of intestinal disorders ("dysentery"). The actual causative microorganisms, such as the typhoid-producing *Salmonella typhosa*, may be extremely hard to detect. Consequently, health authorities routinely check for the presence of certain bacteria that act as "indicators," and these are known as "coliform" bacteria.

Coliform are enteric organisms. This means that they are normally found in the intestines of humans and animals. Even healthy people have an ample supply of coliform in their intestines. Furthermore, a number of these organisms are normally introduced into "raw" sewage water by excreted feces. Not only are coliform always present in sewage but they are always found in the presence of disease-producing bacteria such as Salmonella.

Another reason that coliform are used as indicators of pollution is that they are very resistant organisms and are harder to kill off than the actual disease producers. So, if these organisms are not present in the test sample, health authorities can be reasonably sure that no other sewage pollution bacteria are present either.

Tap water, if properly treated, is free of coliform bacteria, while raw or untreated water contains an appreciable number. In this experiment, we isolate and grow coliforms from a selected water source by trapping them on the surface of a membrane filter for culturing into identifiable colonies.

In addition to promoting growth of coliform organisms, the MF-Endo medium used for coliform culture is selective in discouraging the growth of most other species of bacteria. This is a significant help in such tests because raw water sources contain hundreds of different species of microorganisms having nothing to do with pollution. These organisms would otherwise completely overgrow the test filter and mask the presence of any coliform colonies. How does MF-Endo medium work? Years ago, researchers learned that coliform bacteria have the particular ability to break down a complex sugar called lactose, forming a number of simpler substances, among which are a group of chemicals known as aldehydes. The MF-Endo medium contains lactose and other nutrients, and also a stain, basic fuchsin, which reacts with the aldehyde molecules and forms a complex that appears as a shiny green coating. Because few microorganism make aldehydes out of lactose, other than members of the coliform family, the "green-sheen" colonies are quickly identified as coliform bacteria. The mere presence of coliform colonies, however, does not mean that the water is polluted. All open bodies of water are subject to animal excretion as well as seepage from soil. What is important in assessing the possible pollution level of the water is the number of coliform found in the sample. When the number of coliform exceeds the standards set for particular areas and types of water, health officials assume that disease-producing bacteria are also present. Additional tests are then performed to isolate and culture the pathogens.

Procedure

The following procedure is very similar to the coliform test performed daily in pollution-testing laboratories all over the world.

1. Sterilize a Sterifil filter holder in an autoclave or by immersing it in boiling water for 3 min. If this is not practical, such as in a field experiment, dip the Sterifil in 70% alcohol for a few sec, shake it off, and let it air dry.
2. Load the Sterifil holder with a type HA (0.45 mm) membrane filter. When handling the filter, be sure to use forceps that have been sterilized by dipping in alcohol.

3. Using sterile forceps, place a sterile absorbent pad in a 47-mm petri dish. The pads are supplied in the same envelope with the membrane filters.
4. Break open an ampule of MF-Endo medium and pour the contents (2 ml) onto the absorbent pad. As an alternative, you can prepare a stock solution from powdered MF-Endo medium and pipette 2 ml of this solution onto the pad. Close the petri dish and set it aside until step 8.
5. To the Sterifil funnel, add about 20 ml of sterile water or tap water that has been boiled for several minutes. The exact volume added is not critical. Its purpose is only to evenly disperse the bacteria present in the measured sample.
6. Into the Sterifil funnel, pipette an aliquot of the sample water taken from a pond or stream. Swirl the funnel to mix the sample with the sterile dilution water. The size of the aliquot will vary with the contamination level of the water being sampled. To determine proper sample size, start with an aliquot of 1 ml. After your first cultures have grown, you can determine whether a larger or smaller sample size should be used. Adjust the sample size to get no more than 20 to 80 coliform colonies growing on the filter surface. The total of all colonies, including coliform, should not exceed 200. Alternately, your first experiment can be run with 0.1, 0.5, 1, and 2 ml to determine the optimum sample size. Furthermore, you may want to determine the coliform level in water from different sources. As a general rule, the following sample sizes are recommended:

    For untreated water (fresh or salt water), use 1 ml of sample added to the dispersion water prepared in step 5 above.

    For well water or natural spring water, use a sample size of 50 ml (omit step 5).

    For chlorinated tap water, a much larger sample size is required, at least 500 ml (omit step 5). Here it is necessary to complete the filtration in several steps, since the Sterifil receiver flask will only accomodate 250 ml. If your lab is equipped with an aspirator or vacuum pump, then the entire sample can be filtered at one time by attaching the top portion of the Sterifil unit to a standard 1-liter filtering flask. Ideally, you should find no coliform colonies in drinking water. If you do find coliform colonies in excess of 4 per 100 ml of original sample, you should suspect poor technique rather than polluted water.
7. Using a hand vacuum pump or some other suitable vacuum source (such as a water aspirator), apply vacuum to the Sterifil receiver flask. This causes the water to flow through the filter, leaving the bacteria trapped on the filter surface.
8. After filtering the test sample, release the vacuum by removing the vacuum pump tubing from the side-arm of the Sterifil receiver flask. Unscrew the funnel and, using alcohol-dipped forceps, lift the filter from the Sterifil base and place it grid-side up on the saturated absorbent pad in the petri dish. Carefully line up the filter with one edge of the petri dish and set it down

with a slight rolling motion so that it is evenly centered. Replace the cover.

9. Invert the petri dish and allow the culture to incubate for 48 hr at room temperature or for 24 hr at 37°C in an incubator. The medium supplies all areas of the test filter with needed nutrients, passing directly through the filter to the microorganism on its surface. The petri dish must be inverted, because incubation often causes moisture condensation inside the closed dish. If the dish were right side up, droplets could form that might fall onto the filter surface, spoiling the appearance of the developing colonies. After the colonies have developed, remove the test filter and allow it to dry on a clean blotter or paper towel for 1/2 hr.
10. With a hand magnifier or low-power microscope (10X), scan the surface of the filter for colonies having a shiny, greenish surface. Count the total number of these "green sheen" colonies on the filter.

Calculations

To figure the number of coliform bacteria present in the water tested, use the following formula.

$$\frac{\text{No. of Coliform Counted} \times 100}{\text{Milliliters of Sample}} = \text{No. of Coliform/100 ml}$$

Example: A 2-ml sample was added to the filter funnel containing approximately 20 ml of sterile water. After incubation 48 sheen colonies were counted on the Millipore filter. Therefore, (48 x 100)/2 = 2400 coliform per 100 ml.

NOTE: Standards vary from one municipality to the next. Check with your local officials to determine what the standards are for your area for different types of water (untreated water, well water, drinking water, and public swimming areas).

Making Permanent Records

To preserve the result of your experiment for future reference or to attach to a report, use the following technique:

1. Saturate a piece of blotting paper or an absorbent pad with a solution of 20 parts glycerine, 40 parts formaldehyde, and 40 parts water.
2. Using forceps, remove the specimen filter from the petri dish and set it down on the saturated blotter pad for 2 min.
3. Remove the filter and set it down to dry on a clean, dry blotter pad.
4. The dry filter can now be preserved between glass slides or permanently affixed to a report using a 3" x 3" piece of transparent contact paper (available at most hardware stores).

Cleaning up

Cultures, whether on filters or in any other medium, should be considered potentially dangerous and handled with the utmost care. After completing the experiment, you should destroy or deactivate the cultures. The plastic petri dishes should be resterilized using the following procedure:

1. Carefully remove the petri dish covers using the back of the flat-bladed forceps as a prying tool. Put the covers and dishes (with cultures) into a large beaker or pan containing undiluted liquid household bleach for 10 min.
2. Then, using tongs or a rubber glove, remove the petri dishes and covers. Rinse well under running water. Put the wet pads and filters into a plastic bag and discard.
3. Immerse the petri dishes and covers in a solution of 70% alcohol for 10 min.
4. Remove the petri dishes and covers and stack them on a clean surface. Once dry, assemble them; they are again ready for use.

Suggestions for Further Projects

1. Anderson, J. W., and Heffernan, W. P., "Isolation and Characterization of Filterable Marine Bacteria." Journal of Bacteriology, Dec. '65, p. 1713.
2. Rose, R. E., "Effective Use of Millipore Membrane Filters for Water Analysis." Water & Sewage Works, Reference Number 1966.

G. Water Ecology - Pond and Stream

J. Russel, Gaithersburg High School, Gaithersburg, MD

Purpose: To measure and compare a "basic" stream and a "basic" pond study and to then assess the physical, chemical, and biological aspects of both in order to gain an understanding of freshwater ecology.

Pond Study

Purpose: To identify and observe the relationships existing among the physical, chemical, and biological factors in a pond or small lake. At the completion of this study you should be able to:

1. Create a map of the pond or lake.
2. Calculate a diversity index (DI_t).
3. Analyze the water for and have data on physical and chemical characteristics such as: dissolved oxygen (D.O.), pH, total suspended solids (TSS), total dissolved solids (TDS), total hardness (TH), carbon dioxide (CO_2), temperature, alkalinity, phosphorus, potassium, nitrogen, and plankton sample.
4. Using a data sheet, describe and analyze the major flora and fauna found.
5. Discuss in a summary paragraph the unique characteristics of a limnetic biome.

Process

1. Mapping - Map the pond. Use graph paper and map to scale. Show the general location and include the immediate area around the pond. Note and locate the streams, etc., flowing in or out of the pond and record any obvious sources of pollution. Mark the specific area from which your group takes the water sample.
2. General Observations - What are the typical plants in the pond? What are the typical animals you observe? Generally describe the area. Is it sunny or shady? What is the basic appearance of the pond? Also describe the general area around the pond. Is the pond surrounded by field, forest, or what? Refer to A Guide to the Study of Freshwater Ecology (Andrews, William A., Prentice-Hall, Inc., Englewood Cliffs, N.J., 1972), which is available for help.
3. Sampling - Choose an area of the pond where the water is at least 1 to 2 feet deep. You are free to choose the particular site you wish to sample. Take your water samples and perform the following tests: D.O., free CO_2, pH, alkalinity, temperature, TSS, TDS, nitrate, phosphorus, potassium, bacterial sample, species diversity index, TH, turbidity and transparency of the water, and a plankton sample.

   The hach kit contains materials to test for D.O., CO_2, alkalinity, and TH. The soil test kit contains materials to test for nitrate, potassium, phosphorus, and pH. A Guide to the Study of Freshwater Ecology contains instructions for TSS (p. 94) and TDS (p. 95).

   Turbidity and Transparency is simply a subjective observation that you will make. How clear is the water? Can you see the bottom? What color is it?

   Bacterial Sample - Take a few drops of the water and place on a sterile petri plate and incubate. Are there any large colonies? Is there a large number of colonies? Are any of the colonies exhibiting an antibiotic effect? If so, test this by transferring the colony to a new plate.

   Plankton Sample - Gather a sample of the plankton to observe back in the lab. Is it mostly zooplankton or phytoplankton? Why do you think so? Is there a large diversity in the number and types of plankton? Why are plankton so important to a pond ecosystem?

   Species Diversity - In a well-balanced ecosystem, one expects to find a high species diversity. A high diversity is a large number of species and a relatively small number of individuals in each species. The following method is a sequential comparison index for determining the species diversity:

   Using an enamel pan with lines drawn across the bottom, dump a bottom sample into the pan and compare the organisms that are lying side by side. Start at the extreme left of one row and use an X to represent the first organism. If the organism lying next to it is the same, represent it with another X, if it is a different organism represent it with an O. Now compare the second and the third organism in the line. If the first organism is an X and the second an O, now look at the third. If the third organism is like the second, use another O; if it is different, use an X (regardless of the fact that the third and first organism may not be the same). Continue down the row, comparing each organism to the one immediately preceding it.

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For each row, calculate the number of organisms and the number of runs. A run is each time that you change from an X to an O (or reverse), e.g., Row 1 XOXOXOX 7 runs

7 specimens

Row 2 XXXOOXXX 3 runs

8 specimens

After you have counted 50 specimens, calculate DI_1 (Diversity Index 1):

$$DI_1 = \frac{\text{number of runs}}{\text{number of specimens (50)}}$$

Now count another 50 specimens and calculate DI_2. Do this for approximately 250-300 specimens. Now average all your DI values. To obtain the final diversity index DI_t, take the DI (the average of all of the Diversity Indices) and multiply this value by the total number of taxa that were observed. Therefore, before you dump the sample, you must count the total number of different taxa in the tray, and keep track of the total. Any DI_t value above 12 is considered clean and any DI_t value below 8 is considered dirty.

Temperature - Take the temperature of the water at the surface and, if possible, move out into the water and take temperature readings every 1 foot. Is the thermocline present? Why or why not? What stage of overturn is the pond in at this time?

NOTE: When you take water samples, BE SURE to completely fill the bottle and cap it under water. Do not allow any air into the sample bottle. Why?

Discussion and Evaluation

1. What is the trophic state of the pond? Why do you think so? Use your data to support your answer.
2. Is the pond polluted? How do you determine this?
3. Would you swim in this pond? Why or why not?
4. Write a summary paragraph describing the unique characteristics of this pond.
5. Choose a particular aspect of the pond ecosystem and then elaborate on and design your own task sheet that with additional tests, surveys, etc., could be used to give a more complete picture of this pond.

Stream Study

Purpose: To identify and observe the relationships existing among the physical, chemical, and biological factors of a stream. At the completion of this study you should be able to:

1. Create a map of the stream.
2. Calculate a diversity index (DI_t).
3. Analyze the water for and have data on physical and chemical characteristics such as: D.O., pH, TSS, TDS, temperature, TH, free CO_2, alkalinity, phosphorus, potassium, nitrogen, plankton sample, velocity of flow, volume of flow, cross-sectional profile, bacterial sample, species diversity index, bacterial sample.

4. Using the data sheet, describe and analyze the major flora and fauna found in the stream.
5. Discuss in a summary paragraph the unique characteristics of a stream community.

Process

1. Mapping - Map to scale the immediate area of the stream you are studying. Include the width, depth, and the type of shoreline. Mark any landmarks and note any sources of pollution. Once you have chosen the type of area (pool, riffle, etc.) from which to take your samples, mark the area on your general map.
2. General Observations - What types of plants and animals live in and around the stream? What type of stream bed is it? What is the surrounding ecosystem like? Is it field? Or forest? Or what? Refer to A Guide to the Study of Freshwater Ecology to help you make some of these general observations.
3. Sampling - Take water samples and perform the following tests: D.O., free CO_2, TSS, TDS, TH, temperature, nitrogen, phosphorus, potassium, alkalinity, turbidity and transparency, velocity and volume of flow, cross-sectional profile, pH, bacterial sample, species diversity index, and a plankton sample.

   The hach kit has materials to test for D.O., CO_2, alkalinity, and TH. The soil test kit has materials to test for pH, phosphorus, potassium, and nitrogen.

   A Guide to the Study of Freshwater Ecology contains instructions for TSS (p. 94), TDS (p. 95), velocity of flow (p. 101), volume of flow (p. 103), and cross-sectional profile (p. 105).

   Other tests are described within this task sheet, such as: turbidity and transparency, bacterial sample, plankton sample, and species diversity index.

Discussion and Evaluation

1. Is this stream healthy? Why do you think so?
2. Write a summary paragraph describing the unique characteristics of this stream. Be sure to include the effects of each of the 7 characteristics of streams (see A Guide to the Study of Freshwater Ecology).
3. Choose a particular aspect of the stream ecosystem and then elaborate on and design your own task sheet that, with additional tests, surveys, etc., could be used to give a more complete picture of this stream.

Conclusion

1. Assess the measured characteristics of the pond and the stream. How are the two systems similar? How do they differ?
2. Which of the two ecosystems seems to be the most productive? Hypothesize as to why this is so.
3. Predict what each of these ecosystems will look like 10, 25, 100 years from now.
4. Which of the areas had the higher diversity index? List several hypotheses as to why this is so.

5. Elaborate on how each of these freshwater biomes is affected by the immediate terrestrial ecosystem.
6. Assess the physical characteristics of each ecosystem and elaborate on how these may affect the variety of living things found in each system.

H. Plant Hormones and Hydroponics

J. Russel, Gaithersburg High School, Gaithersburg, MD

Purpose: To test the effects of various plant hormones on selected germinating seeds and growing plants. Seed examples may include the pea, bean, corn, squash, or oat. Hormones tested may include 1AA, IBA, and gibberellic acid. Observations are to be made on the root, stem, and leaf.

Interpretations: Observations will include linear and weight measures. Pressing the plant after the significant data have been taken will be helpful for later reference. What observations and symptoms of the plants show hormonal regulation of biochemical processes? In addition to the hormone supplement, what nutrients, water supply, or light source might enhance the plant's growth? How might your findings be relevant to agriculture? With respect to the amount and kind of hormone or household product used, what is the ideal "recipe" for growth of the "best" plant? What do the computer data reveal about the experience that might not have been known if the computer had not been used?

Materials

Fine-needle syringe (Discarded insulin syringes are good.)
Razor blade or sharp scalpel
Standardized nutrient solution

1. First, make up 1% solutions of the following salts:

    $Ca(NO_3)_2$
    KNO_3
    K_2HPO_4
    $MgSO_4$
    KCl or $CaCl_2$
    $Fe(NO_3)_3$ or $FeCl_3$

2. From the stock 1% solutions of each salt, the student will mix as needed a bottle of standardized nutrient solution which includes:

    50 parts $Ca(NO_3)_2$
    50 parts KNO_3
    25 parts K_2HPO_4
    25 parts $MgSO_4$
    5 parts KCl or $CaCL_2$
    1 part $Fe(NO_3)_3$ or $FeCl_3$

3. 5-10 ml of standardized nutrient solution is needed per each hydroponic setup.

Seeds (bean, pea, corn, squash, or oat) (Plants grow hydroponically in the nutrient solution.)

Plant Hormones Tested

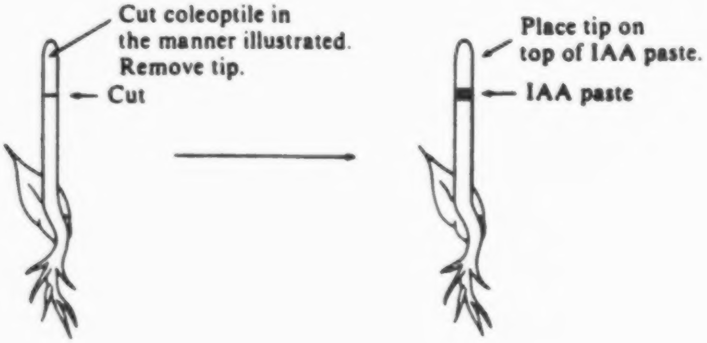
IAA (indoleacetic acid) - 0.01% solution, or IAA paste: 1 teaspoonful of lanolin with IAA sprinkled on the top, then mixed
IBA (indolebutyric acid) - 0.01% solution
Gibberellic acid - 0.01% solution

Procedure

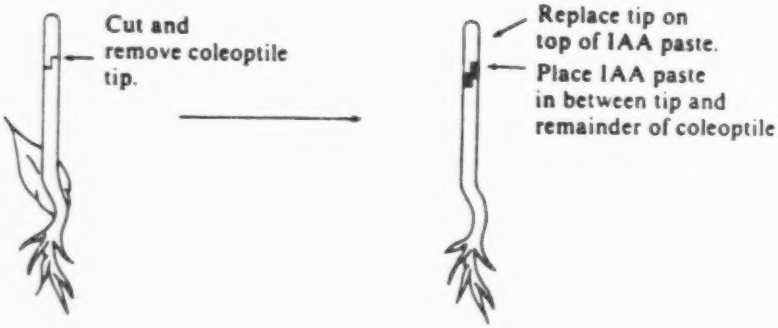
Perform the following operations using one plant per operation. Record the effect on root stem and leaf daily. Each section must have a control plant for comparison. Measure the length and weight of the total plant. Each day record your data in the computer following the program design.

I. Effects of IAA on plant

1. Choose oat or corn (illustrated below).


Cut coleoptile in the manner illustrated. Remove tip.
Cut
Place tip on top of IAA paste.
IAA paste

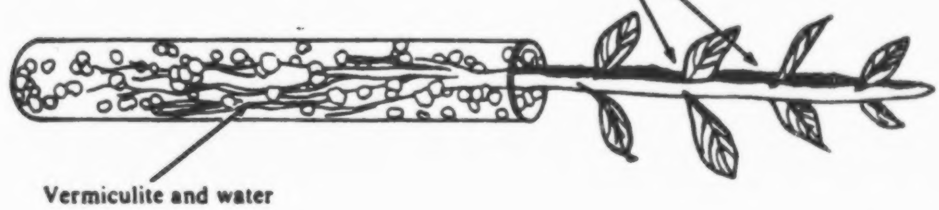
2. Choose oat or corn (same plants as in 1).


Cut and remove coleoptile tip.
Replace tip on top of IAA paste.
Place IAA paste in between tip and remainder of coleoptile

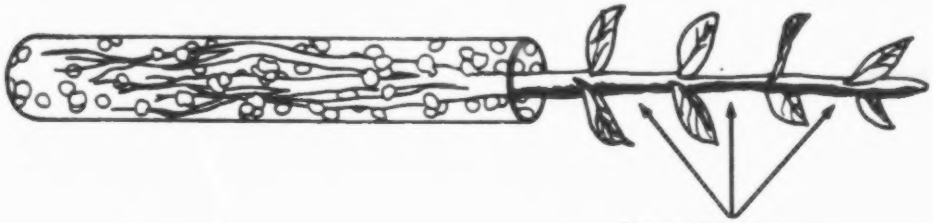
3. **Choose a growing pea plant. Roots are in vermiculite that has been supersaturated with H_2O plus nutrient solution. Plant must remain prone and in a good light source for the duration of the investigation.**

a.

Place IAA paste on the top side of the stem of the plant.



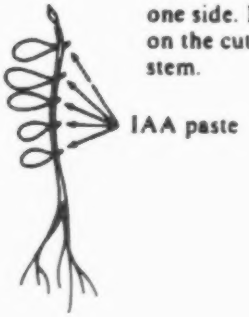
b.



Place IAA paste on the undersurface of the stem of the plant.

4. **Use a growing pea plant.**

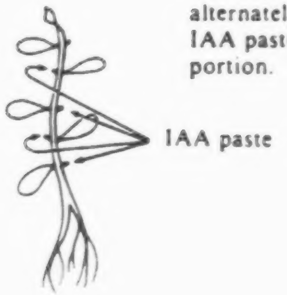
a.



Remove all leaves on one side. Place IAA paste on the cut portion of the stem.

OR

b.



Cut off leaves alternately. Place IAA paste on cut portion.

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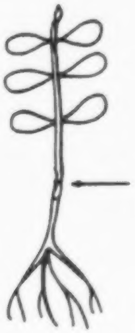
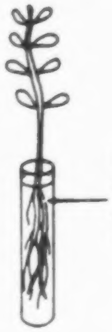
5. Use the same plants as in 3 and 4. The illustration is showing the stem skinned and treated with IAA paste mixture.



Remove the epidermis by scraping. Cover wound with IAA paste.

Summation of Part I: There are approximately 12 known auxins in plant tissue. From your investigations and research, what biochemical processes have been regulated by the addition of hormone(s) to the plants?

II. Effects of IBA on plant growth



Place plant in either IBA solution or gibberellic acid solution. Note any effect on root growth. Compare with control.

Summation of Part II: From your observations, how does IAA differ from IBA? Include growth of specific structure(s) plus rate comparisons. What type of agronomist would be especially interested in adding this hormone to the treatment?

I. Responses of *Daphnia* to Environmental Gradients

E. Smith, Sullivan High School. Chicago, IL

Introduction

The purpose of this experiment is to observe the reactions of *Daphnia* when exposed to gradients of pH, light, and temperature. In the natural environment, gradients of light, temperature. and pH exist. In ponds, light is more intense near the surface and least intense on the bottom. Temperatures, at least in summer, are warmer towards the surface, cooler towards the bottom. There are also differences in pH between the tops and bottoms of ponds. The surface layers, because of the high light intensity, have organisms carrying out photosynthesis. Photosynthesis removes carbon dioxide from the water and raises the pH. The bottom layers are the decomposition zone; carbon dioxide is released there, lowering the pH. Thus, the bottom is more acid than the surface. *Daphnia* living in a pond have optimal ranges for many environmental factors. They have sensory mechanisms that can detect some of the differences in factor intensity. They can respond to these gradients by avoidance behavior; e.g., they move away from an undesirable zone. *Daphnia* may have an optimal range for a particular factor but will be unable to sense a gradient for this factor. In nature, they may clue on another factor, to which they are neutral, to avoid the undesirable zone. It is possible. for example, that *Daphnia* cannot detect pH gradients even though they may be killed by low or high pH. *Daphnia* can detect light, but they are probably neutral to the effects of light. Since high light intensity is associated with high pH, *Daphnia* could use light to clue for pH.

You will place *Daphnia* in tubing containing a gradient of each of the 3 factors under study. You will observe their avoidance behavior by observing their position in the gradient. and determine which factors are avoided and which factors are not.

Materials

Four 1-meter lengths of plastic tubing (e.g.. aquarium air tubing)
Thermometers
pH meter or pH paper
Light meter
2 or 3 floodlights
Ice cubes in plastic bags
Hot water in plastic bags
Syringes
0.1% K_2CO_3
0.1% acetic acid
Petri dishes
Binocular microscope (optional)
Aluminum foil
Glass rods for plugging ends of tubing
Large culture of *Daphnia*
Scissors

Procedures

1. **Setting up the Experiment**
   Four setups are required: a control, a pH gradient, a temperature gradient, and a light gradient. Normally each will be placed on a different table. The students at a given table are responsible for the observations at that table and the instructor will record the data from all the setups on the blackboard.
   a. Control - Fill the tubing with *Daphnia* by inserting one end under water and sucking on the other end. Stopper both ends. Avoid air bubbles. Lay tubing flat on the table for exactly 30 min. Then, measure 25 cm from one end of the air tubing. Raise the tubing slightly at this point and cut. Plug each cut end with a glass rod. Gently return the tubing to the table top and measure 25 cm from this point and make a second cut in the same way. Likewise for a third. You now have four 25-cm lengths of tubing.
   b. pH Gradient - Prepare a tube as described above for the control. Insert an empty syringe at each end. At one end, inject, via a second syringe and needle, 1 ml of 0.1% K_2CO_3 and at the same time remove 1 ml of water. At the other end, slowly inject 0.5 ml of acetic acid while at the same time removing 0.5 ml. Allow to stand exactly 30 min. Proceed as in the controls. Determine the average pH of the fluid in each section.
   c. Temperature Gradient - Prepare a tube as described above for the control. At one end of the tubing, place a plastic bag filled with ice; at the other end place a plastic bag filled with hot water. In each case, cover about 15 cm of the tubing at the end. Proceed as in the controls. Determine the average temperature of the water in each section.
   d. Light Gradient - Prepare a tube as described for the control except that you will use a tube that has one-half of its length modified to reduce light penetration. The distal 25 cm of tubing is to be covered with aluminum foil. The next 25 cm is to be covered with notebook paper. The third segment is to remain as is, and the fourth 25 cm is to be placed under a fluorescent light (care must be taken that the light does not affect the temperature). The light gradient can be estimated by placing a light meter in place of the tubing at the conclusion of the experiment. Four readings are needed, one for each segment. Terminate the experiment at the end of 30 min as described under the control.
2. **Population Counting**
   Hold one end of the tubing over a beaker or petri dish. Remove the plugs. Count the total number of *Daphnia* in each section now in the petri dish. (A binocular microscope is helpful but is not essential). Record the total number for each section of tubing and report these data to the instructor.
   Measure the pH, temperature, and light. Record.
3. **Evaluation of the Data**
   One problem that always arises in any experiment is the evaluation of the data. Are there differences between two values? Usually the opposite problem exists. There appear to be differences, but

are the differences real, i.e., are the differences significant? Was there really an effect of the treatment? Or are the numbers different because of chance variation? We must evaluate the data, using relatively simple statistical tests.

If the experimental procedures do not affect the distribution of *Daphnia*, they should be uniformly distributed along the tubing. If there is an effect of some treatment, some *Daphnia* will be concentrated in certain sections. Thus, for each of the 4 setups, we must decide whether 1) the distribution is uniform or 2) there is concentration of *Daphnia* in some segments.

The statistical tool needed for such an evaluation is the chi-square test, often used in solving for probability problems in genetics. The formula for calculating chi-square (X^2) is given below:

$$X^2 = \frac{(Obs - Exp)^2}{Exp}$$

Where: Obs is the observed value
Exp is the expected value

Explanation and calculations

1) The observed - These are the 4 values (numbers of *Daphnia*) from each of the 4 segments of tubing.
2) Calculate a total - Add the 4 values together to get the total number of *Daphnia* in the tube.
3) The expected - The null hypothesis is always that the experiment has no effect. Therefore, one always "expects" that the *Daphnia* will be uniformly distributed. The expected number of animals in each section of tubing is, therefore, the total divided by 4 (round off to a whole number).
4) $\frac{(Obs - Exp)^2}{Exp}$ Subtract the expected from the observed in each of the four segments. Square the difference. Now divide the square by the expected.
5) Chi-square - You now have 4 calculated values, one for each of the 4 segments. Add to give X^2.
6) Significance - If this calculated chi-square value is less than 7.82, the null hypothesis must be accepted, viz., that the experimental procedure had no effect on *Daphnia* distribution. If this value is greater than 7.82, then the null hypothesis is rejected and we declare that the experimental procedure did have an effect on *Daphnia* distribution. Theory: A value for chi-square of less than 7.82 can be explained by chance variations.

Sample Calculation

Null hypothesis: That light gradients have no effect on *Daphnia* distribution under the stated experimental conditions

	Dark	Diffuse Light	Background	Lamp	Total
# Observed	12	24	48	20	100
# Expected	25	25	25	25	
Obs. - Exp.	-13	-1	23	-5	
$(Obs - Exp)^2$	169	1	529	25	
$\frac{(Obs - Exp)^2}{Exp.}$	6.76	0.04	21.16	0.00	
X^2		27.96			

Comparison: 27.96 > 7.82.
Decision: Reject the null hypothesis.
Conclusion: Daphnia are sensitive to temperature and are capable of sensing a light gradient and moving to a light that is desirable to them.

4. Discussion
   a. From the experimental results, do you conclude that Daphnia can detect and respond to a gradient of temperature? Light? pH?
   b. What is the value in the ability to avoid areas of high or low intensity of each of these factors? Were any factors applied in lethal doses in these experiments?
   c. Would you obtain the same results if more complex experiments had been performed; e.g., an experiment that varied both the light and the pH? Design such an experiment, formulate a hypothesis, and predict the outcome of the experiment.
   d. Of what value are the statistical calculations? Do they aid a scientist in drawing a conclusion? How? What precisely does a statistical analysis allow?
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J. Investigating Genetic Differences in Pea Seeds

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Purpose: To study genetic differences in two kinds of peas. One obvious difference is in the seed coat (either wrinkled or smooth). You will also look for microscopic and biochemical differences that may have some effect on the nature of the seed coat.

I. Obvious Differences

Materials

10 smooth peas and 10 wrinkled peas
4 small beakers or other glass containers
Balance
Paper towels
Labels

Procedure

1. Examine the 2 kinds of peas. What is the obvious difference between them? Is this striking difference between the 2 seed coats the result of different methods of drying the peas? In the next 2 steps, you will begin to answer this question by measuring the amount of water each kind of pea can absorb.
2. Determine the dry weight of the 10 round peas and the 10 wrinkled peas. Record these weights in a table. Place the round and wrinkled peas in separate beakers or jars and add about 4 times their volume of water. Label your jars for the 2 kinds of peas and put the jars aside for 24 hr.
3. After soaking the peas overnight, pour off the excess water from each bottle and empty each jar of peas into a separate pile on a piece of paper towel. Blot off all the surface water from the peas and again determine their weights. Record the weights of the soaked peas in your table with the weights of the dry peas. Determine the % of increase in weight for each kind of pea and record this in the table.

$$\frac{\text{weight difference}}{\text{dry weight}} \times 100 = \%\ \text{increase}$$

Discussion

1. Which seed type, wrinkled or smooth, had the greater ability to absorb water?
2. Is there any conclusive way to find out if this is a genetic or environmental difference? Explain.
3. If both kinds of soaked peas were placed in a drying oven and left for 14 hr, do you think they would again show the differences in seed coat?

II. Microscopic Differences

Materials

Soaked peas (1 smooth and 1 wrinkled)
Scalpel or razor blade
Microscope slide
2 Droppers
Microscope
Wax pencil

Procedure

1. On one end of a microscope slide, mark W for wrinkled and on the other end, S for smooth. Place a drop of water at each end.
2. Cut through a soaked wrinkled seed with a sharp instrument and gently scrape a small amount of the material from the cut surface into the appropriate drop of water, mixing the scrapings well into the drop. Wipe the blade of the instrument clean and repeat the process with the smooth seed.
3. Carefully observe both drops of water with their scrapings under low power of the microscope. Make simple outline sketches showing a few slides prepared by other class members and compare them with yours.

Discussion

1. Which combination of three words from the list below best describes the appearance of the starch grains of the wrinkled seeds? Of the round seeds?
   Compound, simple, whole, divided, oval, round, irregular.
2. Are the starch grains always similar for the one particular type of pea?
3. Is this difference in pea seeds more likely due to genes or environment? Explain how you might do an experiment to make sure.

III. Biochemical Differences

The large starch granules observed in Part II are made up of many starch molecules. The starch molecules form in a plant when starch-forming enzymes cause small sugar molecules to combine. Is there a difference in the activity of the starch-forming enzymes of wrinkled and smooth peas? To determine this, you can extract the enzymes from each type of seed. Then add an equal amount of the 2 enzyme extracts to a supply of simple sugar (glucose). The enzymes should cause the sugar to be changed into starch.

Materials

10 dry wrinkled pea seeds
10 dry smooth pea seeds
2 Droppers
Petri dish with glucose 1-phosphate agar
Centrifuge
Cheesecloth
Mortar and pestle
Graduate cylinder
Iodine solution
Pliers
Beaker
Funnel

Procedure

1. Instructions for glucose 1-phosphate agar
   Add 0.5g of glucose 1-phosphate to 100 ml distilled water.
   Add 2g of plain agar to the glucose 1-phosphate and distilled water.
   Bring to a boil and pour a film of this mixture on petri dishes.
2. Weigh out 5 grams of dry wrinkled peas and 5 grams of dry smooth peas.
3. Crush the peas with the pliers and grind each kind separately with a mortar and pestle until no big pieces remain. (This takes much effort.) Add 20 ml of water to each mass of ground-up peas. Mix well and gently continue grinding with the pestle.
4. Remove the larger particles by filtering the mixture through a layer of cheesecloth into an appropriately marked beaker. Squeeze the cheesecloth to get the maximum amount of liquid. Centrifuge the liquid mixture to obtain a clear solution free of sediment. Be careful not to mix or confuse the extracts from the 2 kinds of peas.
5. If time permits (you need about 40 more min), continue with the remaining procedures. If not enough time remains in the period, mark your containers and store the extracts in the refrigerator until the next day.
6. Mark the outside bottom of the petri dish halves. Mark a W on one half and an S on the other. On the W side of the dish place 4 drops of the extract from the wrinkled seeds directly on the agar-glucose surface. Space the drops so they do not run together. Do the same with the smooth-pea extract on the S side of the dish. Record the exact time that the extract meets the agar.
7. After 10 min, soak up the extract from one drop on the W side and one on the S side. Immediately apply a drop of iodine solution to each spot where the extract was. Place a drop of the iodine solution on the agar surface at a spot where there was no extract. Record your observations.
8. At 10-min intervals, repeat step 5 with the remaining extract drops.

Discussion

1. Was there any difference in the amount of starch formed by the wrinkled and smooth peas? How could you tell?
2. Breeding experiments have shown that all the variations in the peas seen in this investigation are controlled by one gene pair. Which condition - the texture of the seed coat, the shape of the starch grain, or the action of the starch enzyme - is closest to being under the direct influence of the gene?
3. Why do some pea seeds have a wrinkled coat? Is it due to environmental influence, direct gene action, or the secondary effects of some other factor controlled by genes? Explain.

K. Respiration

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I. Anaerobic Respiration in Yeast

Set up 2 thermos bottles as follows: Insert a short piece of glass tubing through one of the holes in each of two 2-hole rubber stoppers. Insert a thermometer through the other hole of the stopper. Add a sterile 20% sucrose solution to each of the 2 thermos bottles, making them about three-fourths full. Add 1 gram of dry yeast to one of the bottles; no yeast will be added to the other. What is the purpose of the second bottle?

Place the stoppers in the thermos bottles so that the thermometers, but not the glass tubes, dip into the liquid. Attach a piece of rubber tubing to each glass tube and place the opposite end of the tubing under water in a flask or beaker.

Prepare a table and record the temperature of both bottles as frequently as possible for the next 48 hr. Graph these data, using different colored lines for the results of the different thermos bottles. Compare the results of the 2 bottles.

What caused the results of these 2 thermos bottles to be different? What evidence is there that energy is being released?

What other products are released in anaerobic respiration by yeast? What simple modification can be made in this experimental setup to indicate one of these products?

II. Aerobic Respiration in Plants

To avoid complications with the process of photosynthesis, "non-green" plants, namely seeds, are studied for this part. Prior to this experiment, the seeds must be soaked for 15 min, then wrapped in damp paper towels to be left overnight before use. This stimulates germination.

a. Put about 2 cm of filtered calcium hydroxide in each of 2 culture tubes. Above this, force a small wad of moistened cotton and lay several germinating seeds on the cotton of one of the tubes. Seal the tubes with plastic wrap and leave overnight. Describe the results.

For what substance is $Ca(OH)_2$ an indicator?

How would you account for the difference in these 2 tubes?

b. Wrap several germinating seeds in a cheesecloth bag, dampen, and suspend the bag from the underside of a 2-hole rubber stopper. Add filtered calcium to a flask. Insert a short piece of glass tubing in one hole and a right-angle tube into the other. Insert the stopper in the flask. With a short piece of rubber tubing and a pinch clamp, seal the short glass tube. Add dye to the end of the right-angle tube until 0.5 cm of the dye has been drawn in. Take readings of the movement of the drop of dye (in mm) at appropriate timed intervals. Make a table of your results, then graph the results. Describe the movement of dye through the tubes.

How do you account for the movement of the dye through the tube? (Explain fully.)

Describe a control for this experiment.

Estimate the movement of dye through the tube of the control and add a line indicating it to the graph of your data.

III. Aerobic Respiration in Animals

a. The products of respiration may be indicated by the following tests:
   (1) Measure the temperature of the room using a Celsius thermometer. Record. Measure the temperature of your breath by holding a thermometer in front of your open mouth for 2 min. Record. How might you account for the difference in these 2 readings?
   (2) Breathe on a piece of glass. Describe. How might you account for this?
   (3) Fill a culture tube about one-half full with filtered calcium hydroxide and blow into it gently through a straw. Describe the change in the solution. The presence of what substance is indicated by this test?

b. The effect of exercise on your ability to hold your breath can be demonstrated by the following procedure. The subject, after sitting quietly and breathing normally for 3 or 4 min, holds his/her breath for as long as possible while the experimenter watches the time. After a rest period, the subject hyperventilates the lungs by breathing deeply with the mouth open at the rate of 15 breaths per min for 2 min. Again the experimenter watches the time. After the next rest period, the subject exercises strenuously for 2 min. Immediately following the 2-min exercise period, the subject again holds the breath as long as possible. Experimenter and subject then exchange roles. Record the times below.
   1) Before exercise
   2) After hyperventilation
   3) After exercise

   Explain the difference between these 3 times.

c. Increase in the rate of breathing after exercise indicates an increased rate of respiration (evolution of CO_2 as a result of an increased oxidation of food). Studies have shown that the percentage of CO_2 per exhaled breath remains constant under conditions of normal breathing, about 4.0% If one assumes that the volume of exhaled air per breath is the same (the average is 500 ml normal and 1,000 ml after exercise), you can calculate the amount of CO_2 exhaled per min as follows:

   # breaths/min x volume/breath x % CO_2 in exhaled air

   The subject sits relaxed for 5 min. The experimenter then counts the number of breaths for 2 min and obtains an average per min. Record.

   The subject then performs some strenuous exercise for 2 min. The experimenter then counts the breaths for 2 min and again obtains an average per min. Record.

   Experimenter and subject then exchange roles. Calculate the amount of CO_2 exhaled per min before and after exercise by using the above formula. Record on the master ditto sheet so that the entire class may have each student's data. Determine the class average.

When a carbohydrate is respired, the volume of CO_2 produced is equal to the volume of O_2 used. Thus the respiratory quotient (CO_2/O_2) is 1. Oxidation of fats and proteins requires considerably more oxygen, producing a respiratory quotient of less than 1. If one assumes that the subject is respiring sugar, what is the volume of oxygen used in 1 min?
What is the class average?
How much is used during 1 min of exercise?
Class average?
How might such data be useful?

d. To compare the amount of CO_2 in exhaled air with that in inhaled air, set up 2 flasks using 2-hole rubber stoppers, inserting glass tubing into each hole so that only the longer tube extends into the flask, about 1 cm from the bottom. Measure 100 ml of distilled water into each flask and add 3 drops of phenolphthalein to each. Phenolphthalein is a pH indicator with a range of 8.3 (colorless) to 10.0 (pink). Connect the long glass tube of one flask and the short glass tube of the other with rubber tubing to a Y-shaped tube. Use the leg of the Y to mouth-breathe for 1 min, inhaling for 5 sec and exhaling for 5 sec. Then, using a 0.4% NaOH solution, titrate the contents of each flask to the same degree of color change. Swirl the contents of the flask after adding each drop. Calculate the percentage increase of CO_2 in exhaled air. Show your work completely, including measurements of the amount of NaOH used in the titrations. One ppm of CO_2 is one part of CO_2 in a total of one million parts of water. Each ml of 0.4% NaOH solution chemically combines with 100 ppm of CO_2. Calculate the amount of CO_2 in ppm in the flask with inhaled air.
Calculate for the flask with exhaled air.
What produces the difference in these amounts?

L. Isolation and Identification of DNA

Adapted by D. R. Helms, Biology Program, Clemson University, Clemson, SC, from John M. Clark and Robert L. Switzer, Experimental Biochemistry, W. H. Freeman and Co.

Purpose: To allow students to observe molecules of the hereditary material, DNA. Students will use two colorimetric tests to test for the presence of DNA and RNA (which is often isolated along with the DNA).

Two reagents, diphenylamine and orcinol, are used to determine the presence of DNA and RNA, respectively. Diphenylamine reacts with deoxypentose sugars such as those found in the backbone structure of DNA to yield a blue color. Orcinol reagent turns green in the presence of pentose sugars such as those in RNA. Thus diphenylamine and orcinol can be used to qualitatively distinguish between RNA and DNA.

Materials

Tryptic soy broth (Carolina Biological Supply, 78-8441, 1 lb/$11.15; use 30g/liter)

Escherichia coli (Carolina Biological Supply, 15-5065, tube/$4.40): suspend with enough tryptic soy broth to make a turbid mixture. Use 1 ml to inoculate 100 ml media. Incubate at 30° for 24 hr.

25% SDS solution (Fisher, sodium lauryl sulfate, S-329, 500 g/$16.70)

Cold ethyl alcohol (95%)

4% NaCl

5-*M* $NaClO_4$ (Fisher Scientific Company S-360 500 g/$31.65: 70.2 g/100 ml water)

Lysozyme (Sigma Chemical Company, L6876, 1 g/$6.20) - prepare a solution 10 mg/ml in distilled water

Chloroform/isoamyl alcohol (50:1)

50-ml Erlenmeyer flask

Glass stirring rod (Scratch end to make winding of DNA easier.)

Isolation of DNA

1. Place 25 ml of a 24-hr *E. coli* broth culture in a 50-ml Erlenmeyer flask. Add 0.2 g NaCl and 0.9 g Na_2 EDTA to the flask and swirl.
2. Add 1 ml lysozyme solution (10 mg/ml) to the flask. Swirl.
3. Incubate 30 min at 37°C (swirl occasionally). Use water bath on demonstration bench. Make sure you use the bath set for 37°C.
4. Add 2 ml 25% SDS. SDS denatures proteins and inhibits enzymes (nucleases that might break down DNA).
5. Incubate 10 min at 60°C. Use water bath on demonstration bench. Swirl occasionally. Notice that the viscosity increases.
6. Add 7.5 ml of 5-*M* $NaClO_4$ and stir.
7. Add an equal volume (35 ml) of chloroform/isoamyl alcohol (50:1).
8. Shake well.
9. If you have access to a centrifuge, centrifuge the mixture at 10,000 rpm for 10 min. A protein pellet forms at the interface between the two solutions. Remove the clear aqueous upper phase (this contains the DNA) and save in a beaker. If you do not have access to a centrifuge, allow the solution to settle out and pipette out the clear aqueous phase (upper layer) and place in a large glass test tube or beaker. This will take approximately 45 min.

*10. Add two volumes of cold 95% ETOH slowly down the side of the beaker or tube containing the aqueous phase.

11. Stir with a glass rod (heated or acid washed to remove any nucleases). Stir gently and spool out the DNA. Scoring the end of the glass rod with a diamond pencil will make it easier to spool out the DNA.

*The teacher might prepare materials to this point if time does not permit the class to take part in the entire exercise. The cold aqueous phase can be stored in the refrigerator overnight. DNA will precipitate out when the students add the cold 95% ETOH the next day.

COLORIMETRIC TESTS FOR DNA AND RNA

Materials

1. DNA standard - store frozen - will keep for a few yr.
   0.1 g DNA to 200 ml distilled H_2O (place 1 drop glacial acetic acid to every 200 ml) - may need to heat to get into solution
2. RNA standard - store frozen - will keep for a few yr.
   0.1 g RNA to 200 ml distilled H_2O (place 1 drop glacial acetic acid to every 200 ml) - may need to heat to get into solution

   Sigma Chemical Co.

DNA	D1626	250 mg/$ 4.00
		1 g/11.00
RNA	R6626	25 g/2.00

   or

   Fisher (pretty impure - have never used these but could try)
   DNA (Sodium salt) 11453 25 g/$8.65
   RNA (10010-P 500 g/$7.65)
3. Diphenylamine - Fisher 0-2611 100 g/$14.50
   (1) Dissolve 15 g diphenylamine in 1,000 ml glacial acetic acid (use new bottle).
   (2) Add 15 ml concentrated H_2SO_4 (new bottle).
   (3) Store in dark bottle.
   (4) On day of use, add 1 ml acetaldehyde (Fisher 0-1004 250 ml/$10.10 - keep in fire cabinet) solution (1 ml acetaldehyde to 500 ml distilled H_2O) per every 100 ml diphenylamine.
4. Orcinol
   (1) 5g of $FeCl_3$ to 1,000 ml concentrated HCl
   (2) Prepare fresh before use:
   0.1 g orcinol + 10 ml $FeCl_3$ solvent

I. Diphenylamine Test for DNA

1. Pour 3 ml of 4% NaCl into a clean test tube.
2. Use an applicator stick to remove some of your isolated DNA from the glass stirring rod and redissolve this material in the NaCl.
3. Mark the tube with an I to indicate that it contains your isolated material.
4. Place 3 ml of a DNA standard solution into a 2nd test tube and 3 ml of water into a 3rd test tube. Mark these with an appropriate indication of contents. These tubes will provide you with a standard and a control with which to compare results.
5. Add 3 ml diphenylamine reagent to each tube.
6. Boil for 15 min.
7. Compare colors in tubes and record results.

II. Orcinol Test for RNA

1. Pour 2 ml of 4% NaCl into a clean test tube.
2. Dissolve part of your isolated nucleic acid in the NaCl. Label.
3. Place 2 ml of the RNA standard solution in a 2nd test tube. Label.

4. Place 2 ml distilled water in a 3rd tube. Label.
5. Add 2 ml orcinol reagent to each tube.
6. Boil for 20 min.
7. Compare colors in tubes and record results.

Did you get a positive test for DNA when you compared the results of your test on the isolated material and DNA standard?____________________

Did you get a positive test for RNA when you compared the results of your test on the isolated material and RNA standard?____________________

How do you explain the above results?____________________

Why was the water used in one of the tubes in each test?____________________

What was the role of the lysozyme during the isolation?____________________

M. Determining the Cellular Concentration and Osmotic Potential of Plant Tissues

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Purpose: To determine the cellular solute concentration and osmotic potential of plant tissues.

Maintaining water balance is one of the important problems that organisms must solve as they adjust to their environments. However, it is often difficult for students to visualize how such a biologically vital substance as water can pose a severe threat to the integrity of cells. A cell placed in a solution that is not isotonic to it may adjust to the changed environment by undergoing a change in its water content (swelling or shrinking), so that it finally reaches the same concentration of solutes as its surrounding fluid. The effect is graphically demonstrated by this experiment, and the student will be able to determine the cellular concentration and calculate the osmotic potential of plant tissues. The experiment can be used to demonstrate the relationship between hypertonic, hypotonic, and isotonic solutions, and it also provides an open-ended research opportunity for additional individual investigations by students.

Materials

1-M Sucrose (342 g/liter distilled water)
Petri dishes (10) or other small containers
Plastic wrap
Thermometer
Potatoes
Cork Borer
Knife

Procedure

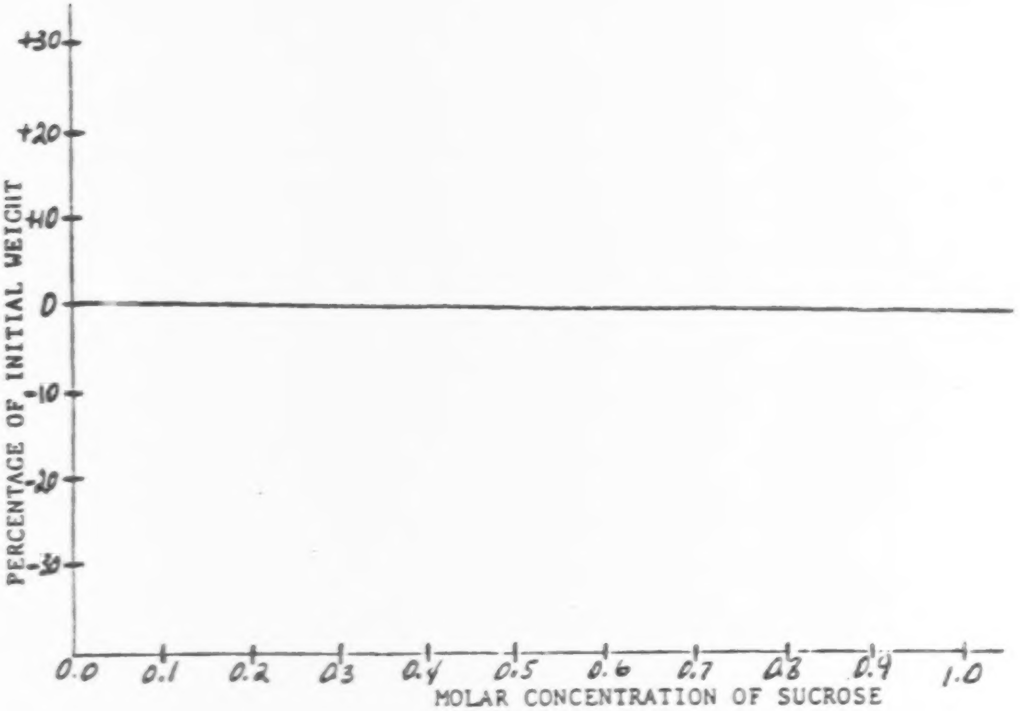
Prepare the following series of sucrose solutions: 1.0 M, 0.8 M, 0.7 M, 0.6 M, 0.5 M, 0.4 M, 0.3 M, 0.2 M, 0.1 M. These can be prepared by using distilled water and 1.0-M sucrose solution. (The 1.0-M sucrose solution can be prepared by adding 342 g of sucrose to enough distilled water to make 1 liter of solution.) Also, use a control solution of distilled water. The number of solutions can be reduced without jeopardizing the final results of the experiment (e.g., 0, 0.2 M, 0.4 M, 0.6 M, 0.8 M, 1.0 M).

Using a cork borer, cut cores from fresh potatoes. Slice the cores 1 mm thick. Cut enough slices from the cut cores so that you will have about 30 slices to place into each solution. Weigh each group of 30 slices and place in separate petri dishes. Add about 20 ml of each solution to each of the petri dishes containing the potato slices. Allow the dishes to stand overnight (24 hr maximum) at room temperature. Cover the dishes to prevent evaporation. At the end of the time, remove the slices in groups, blot each group free of excess solution, and weigh.

TABLE 1. Weight of potato tissue samples before and after treatment in sucrose solution of different concentrations.

Sucrose Molarity	Initial Wt.(g)	Final Wt.(g)	Diff.(g)	% of Initial Weight
1.0	4.40			
0.9	4.77			
0.8	4.37			
0.7	4.28			
0.6	4.11			
0.5	3.61			
0.4	3.49			
0.3	4.54			
0.2	4.36			
0.1	4.15			
0.0	3.92			

Determine the weight change for each sample and calculate the value of the change in terms of the percentage of the initial sample weight. Plot the percentage gain or loss of each sample as a function of the molarity of the solution in which the samples were immersed.



Graph the percentage weight gain and loss of potato tissue samples related to the molarity of the sucrose solution in which they were immersed.

Determine the tissue concentration by examining the graph and noting where the line for a particular tissue crosses the point on the Y-axis representing zero weight loss. The corresponding point on the X-axis will represent a concentration of sucrose isotonic to the tissue. At this concentration, there is no net gain or loss of water from the tissue and turgor pressure may be considered zero. The potential of the solution and hence the cell potential can be calculated from the osmotic concentration by using the formula OP=iCRT (OP=osmotic pressure; i=ionization constant; C=molar concentration; R=pressure constant; T=temperature). The ionization constant for sucrose is 1. (Sucrose does not form ions in water, so for every sucrose molecule added there is only 1 sucrose molecule in solution). The pressure constant is a handbook value (R=0.082). The temperature is to be determined on the Kelvin scale. The usual thermometer reads °C. The Kelvin temperature = °C + 273. The tissue molar concentration is determined in the experiment.

Other parenchymal plant tissue, such as carrot root, can be used for this experiment. Because the central core of the carrot contains nonliving vascular tissue that will take up water directly, not osmotically, the central core must be removed. Be sure that the tissue is fresh and not dehydrated.

N. Dialysis and the Relation of Molecular Size to Permeability

M. A. Allan and D. R. Helms, Biology Program, Clemson University, Clemson, SC

Purpose: To investigate the diffusion of macromolecules through a semipermeable membrane

Materials

- Dialysis tubing (or mammal intestine)
- 15% Glucose solution (15 g glucose/100 ml distilled H_2O)
- IKI - (iodine-potassium-iodide solution) Carolina Biological Supply Co. 86-9051, 30 ml/$2.50
- Benedict's solution - Carolina Biological Supply Co. 84-7121, 500 ml/$10.65
- 6% Starch solution (6 g/100 ml distilled H_2O)
- Beakers (or jars)
- Droppers
- Rubber bands

Tie a knot in one end of the dialysis tubing in order to make a bag.

Using the pipettes indicated, fill the bag 1/3 full with 15% glucose; then add starch solution to the glucose solution in the bag until the bag is 2/3 full. Hold the bag closed and gently mix its contents. Record its color in the table that follows. Carefully rinse off the outside of the bag in order to remove any solution that might have spilled down the side while you were filling or mixing.

Fill a beaker 2/3 full with tap water. Add about 4 full droppers of IKI solution to the water. Record the color of this mixture in the table below. (IKI is used to test for the presence of which macromolecule?)

Place the bag in the beaker so that the untied end of the bag hangs over the edge of the beaker. (DO NOT allow either liquid to spill into the other!) Place a rubber band around the lip of the beaker so that the bag is held securely in place.

Check every 10 min until you see a distinct color change in the bag or the beaker. At that time, record the final color of the solutions in the table that follows.

	Original Contents	Original Color	Final Color
Bag	Glucose & starch		
Beaker	H_2O + IKI		

After a color change has occurred, perform a Benedict's test on a sample of the solution in the beaker. Benedict's reagent is used to test for the presence of reducing sugars. (See Sample Laboratory Exercise U entitled Biochemistry of Macromolecules.)

Benedict's Test

1. Place 5 ml of Benedict's reagent into each of 2 test tubes.
2. Add 8 drops of solution from the beaker in the experiment above to one of the test tubes and 8 drops of water to the other test tube. (Why?).
3. Heat the contents in boiling water for 3 min and then allow to cool.
4. Record the appearance and color of any precipitate.
   What is the result of the Benedict's test?

For the questions a and b below, give evidence for your answer from the chemical tests you performed.

a. Which substance(s) diffused through the membrane?
b. Which substance(s) did not diffuse through the membrane?
c. Can molecules be diffusing across the same membrane at the same time yet in opposite directions? What evidence from this exercise illustrated this?
d. What determines which molecule(s) passed through the membrane?
e. Is there a relationship between membrane penetration and molecular weight? What is it?

O. Photosynthesis, Starch Synthesis, and Cellular Respiration in Plant Cells

Adapted by R. C. Armstrong, Biology Program, Clemson University, Clemson, SC, from Paul B. Weisz, Laboratory Manual in The Science of Biology. McGraw-Hill

Purpose: To observe some of the requirements for and products of photosynthesis and cellular respiration.

Part A

Materials

Four coleus or geranium plants (or other plants with fairly broad leaves containing more chlorophyll than other pigments).
10% Glucose solution (10 g glucose + enough water to make 1,000 ml of solution)
IKI Reagent (add 20 g potassium iodide to 500 ml distilled water and stir to dissolve; then add 4 g iodine crystals and enough distilled water to make 1 liter and stir again. Dissolution will take place slowly. Store in dark stoppered bottles)
95% Ethanol (500-1,000 ml)
Hot plates (2)
Petri dishes (6 if exercise done as demonstration or 1-2 per student)
250- or 500-ml beakers (2)

Procedure

Preliminaries

Five days before the lab period: place 2 coleus or geranium plants in the dark and leave until immediately before the exercise is to be done. Be sure the other 2 plants have access to plenty of sunlight.

One day before the lab period: remove 4 leaves from the plants grown in the dark and immerse 2 of the petioles in a 10% glucose solution and the other 2 petioles in water. Keep these in the dark for 24 hr.

Experiment

Place the 4 leaves kept in the dark plus 2 leaves from the light-grown plants into boiling water for 2-3 min; then transfer to hot (not necessarily boiling) alcohol and leave until pigments are removed from leaves (usually 2-3 min). Cover the bottom of 6 petri dishes with IKI and place a leaf in each of the petri dishes with IKI. The leaves will become dark bluish-black in areas where starch is present. The leaves may be transferred to petri dishes containing water after being in IKI solution for several min.

Additional dark- or light-grown leaves may be tested if students are doing the experiment individually or in small groups.

Results

Ask students to record the results of the experiment as follows:

	Starch Present or Absent
Leaves grown in dark, no glucose supplied	
Leaves grown in dark, glucose supplied	
Leaves grown in sunlight	

You may also ask the students to draw a leaf from each of the 3 categories, shading in the areas (if any) that stained blue-black.

Discussion

Ask students to explain the results. If the leaves were variegated, starch was present only in parts of the leaves that were green. (Only plant cells containing chlorophyll can carry out photosynthesis.) In these cells, some of the glucose produced by photosynthesis is used for cellular respiration, some is transported to the cells without chlorophyll as needed for their cellular respiration, and the leftover glucose is assembled into starch and stored in that form. You may point out that glucose is not a direct product of photosynthesis but is easily made by joining two of the 3-carbon molecules (phosphoglyceraldehyde or PGAL) produced in the Calvin cycle.

The following questions may help the students understand the concepts illustrated in the experiment:

1. How can you tell whether or not photosynthesis has occurred in the cells of a plant? Ans. Test for starch with IKI. Glucose is a (indirect) product of photosynthesis, and glucose molecules are the individual components of the larger starch molecule. If starch is present, glucose must have been present and assembled into starch molecules. Photosynthesis is the only process by which cells may produce 6-carbon sugars such as glucose.
2. Why did leaves grown in the dark not contain starch? Ans. All living cells must continuously carry out cellular respiration to meet the ATP demands of many cellular processes. A requirement for cellular respiration is a 6-carbon sugar such as glucose. Whether plant cells are in the light or in the dark, the glucose produced by photosynthesis is continuously used for cellular respiration. When in the dark, cells must depend on sugar that is stored in the form of starch (since photosynthesis is not occurring to provide a steady supply). Plant cells that have been kept in the dark for several days, therefore, will have almost completely depleted their supply of stored starch to keep respiration going.
3. How long could plant cells live if left completely in the dark? Ans. Only until the sugar supply which had been stored as starch was depleted.
4. Is light necessary for the synthesis of starch from glucose? Ans. No; light is necessary for photosynthesis, a product of which is glucose, but if glucose is supplied to the cells from an outside source, some will be used for cellular respiration and any excess can be assembled into starch (shown by dark-grown leaf with petiole immersed in glucose).
5. Does cellular respiration occur in plant cells that have access to light? Ans. Yes; cellular respiration must occur continuously in any cell that is alive. Although some of the glucose from photosynthesis is used for respiration, enough extra glucose is produced by photosynthesizing cells that the excess may be stored (as starch).

Part B (Demonstration)

Materials

Bottles with 2-holed stoppers (2)
Various plant parts (germinating seeds, fruits, etc.)
Limewater (1 liter) $Ca(OH)_2$ (calcium hydroxide) - saturated solution

Glass tubing - 4 straight pieces, each 2-3 in long
500-ml beakers (3)
1 drinking straw
Rubber tubing - 4 pieces, each at least 18 in long
Clamps - 4, one for each piece of rubber tubing

Procedure

Preliminaries

One day before the laboratory period, assemble the apparatus: place stoppers in bottles, insert glass tubing into each of the stopper holes and attach rubber tubing to each upright glass tube. Place plant parts into one of the stoppered bottles and clamp ends of rubber tubing. Leave bottle in dark along with other stoppered and sealed bottle (control) for 24 hr.

Experiment

1) Place 200-250 ml of limewater in a beaker and bubble CO_2 into it by forcing breath into the drinking straw. Note the white precipitate that forms by the following reaction:

$$Ca(OH)_2 + CO_2 \text{ ----------> } CaCO_3 + H_2O$$

Point out to students that CO_2 is given off as a waste product of cellular respiration.
2) Show the stoppered bottles that have been in the dark. For each bottle, put one piece of rubber tubing down into a 500-ml beaker containing 300-350 ml limewater.
3) Attach free piece of rubber tubing from bottle to faucet. Allow water to fill bottle, thus displacing any gas present. Repeat with other bottle.

Results

Ask students to check limewater beakers for a white precipitate. The following questions may be used to help the students understand the experiment:
1) Is CO_2 produced in either bottle? If so, why? Ans. CO_2 is produced in the bottle with plant parts. When CO_2 was displaced into the limewater beaker, substantial white precipitate should have formed. If plant cells are alive, cellular respiration will be occurring, thus using oxygen and giving off CO_2. In the bottle without plants, some CO_2 is normally present in the air, so a small amount of precipitate may be noticeable when gas is displaced into limewater.
2) What results would be expected if the bottle contained dead plant parts? Ans. Dead cells obviously cannot carry out cellular respiration; therefore, no CO_2 would be produced in the bottle. Any precipitate formed in limewater would be due to CO_2 naturally in the air.

3) Since CO_2 is used in photosynthesis, why doesn't the CO_2 in the bottle get used up? Ans. The plant parts were kept in the dark, so no photosynthesis could occur.

P. Effect of Dilution of Enzyme on Digestion

A. D. Smith, Biology Program. Clemson University, Clemson, SC

Purpose: To vary the concentration of the enzyme amylase obtained from saliva and, in 4 dilutions, observe its effect on the hydrolysis of starch.

Materials

- Test tubes (20)
- Pasteur pipettes (6)
- 3% Starch suspension
- Water bath or incubator
- IKI
- Benedict's reagent
- Hot plate
- Paraffin or clean rubber bands
- 1-ml pipettes (5)
- Parafilm
- Distilled water
- Test tube rack

Procedure

1. Collect saliva in a clean test tube. Salivation can be increased by chewing soft paraffin or clean rubber bands. (Filter if necessary).
2. Number 4 test tubes with grease pencil. Into each of the 4 test tubes, pour 9 ml of distilled water. To test tube 1, add 1 ml of saliva; shake the tube thoroughly. With a clean pipette, transfer 1 ml of this diluted solution from tube 1 into tube 2. (Tube 1 is now a 1:10 dilution; tube 2 is a 1:100 dilution.) With a clean pipette, transfer 1 ml of fluid from tube 2 into tube 3; continue until tube 4 has a dilution of 1:10,000. (Shake all 4 dilutions thoroughly.)
3. To each tube of saliva of different dilutions, add 1 ml of a dilute starch suspension. (See special instructions at end of experiment.)
4. For a control, label two more test tubes 5 and 6. Place 9 ml of distilled water in both tubes. Transfer 1 ml of saliva into tube 5 and 1 ml of starch suspension into tube 6.
5. Incubate all the tubes in a water bath maintained at 38°C (100°F) or in an incubator for 30 min.

Obtaining Results

Part A: Benedict's reagent is used to indicate the presence of reducing sugars but not the presence of starch. When Benedict's reagent is heated with a reducing sugar, such as glucose, the color of the reagent changes from blue ---> green ---> yellow ---> orange ---> r depending on the amount of sugar present. (The orange and red indicate a large amount of sugar.) When heated with starch, Benedict's reagent does not change from its normal blue color.

1. Set up a row of 6 test tubes. Number the tubes 1 through 6 with grease pencil.

2. Transfer 2 Pasteur pipettes of the solution from test tubes 1-6 from the incubator or water bath to the 6 empty tubes, respectively.
3. Add 1 dropper of Benedict's reagent to each tube.
4. Mix the solutions in each tube and record the color of each tube in Table 1.
5. Heat all 6 test tubes in a boiling water bath for approximately 2-5 min.
6. Note any color changes and record the final color of each tube in Table 1.

Part B: IKI changes from a brownish or yellowish color to blue-black when starch is present. but there is no color change with sugars.

1. Set up a row of 6 test tubes. Number the tubes 1 through 6 with grease pencil.
2. Transfer 2 Pasteur pipettes of the solution from test tubes from the incubator or water bath to the 6 empty tubes, respectively.
3. Record the color or appearance of these 6 tubes in Table 1.
4. Add several drops of IKI and note any color changes which will occur almost immediately. (It is not necessary to heat the IKI.)
5. Record the resulting color changes in Table 1.

Recording Results

Table 1

Tube #	Benedict's Test		Iodine Test	
	Original Color (Before Boiling)	Final Color (After Boiling)	Original Color (Before IKI Addition)	Final Color (After IKI Addition)
1				
2				
3				
4				
5				
6				

Interpreting Results

1. Which of the 4 dilutions resulted in the largest amount of reducing sugar?
2. Which of the 4 dilutions resulted in the largest amount of starch?
3. On what evidence do you base your answers for questions 1 and 2?
4. How might you explain a positive test for sugar and also a positive test for starch in the same test tube?
5. What effect does the concentration of an enzyme such as amylase have on digestion?

Special Instructions

1. To prepare a 3% starch suspension
   - Add 3 grams of starch to 50 ml of cold distilled water.
   - Boil 50 ml of distilled water.
   - Add the two together while stirring.
2. To prepare IKI
   - Add 3 grams of potassium iodide to 400 ml of distilled H_2O.
   - Add 0.6 gram of iodine.
   - Stir until dissolved.
   - Store in a dark bottle.
3. To obtain Benedict's reagent
   - Order from Fisher Scientific, 500 ml/$7.20

Q. Transpiration

Adapted by R. C. Armstrong, Biology Program, Clemson University, Clemson, SC, from C. Eberhard, Biology Laboratory, A Manual to Accompany Biology, Karen Arms and Pamela S. Camp

Purpose: To demonstrate transpiration.

Materials

Geranium or coleus plant(s) (2 if demonstration or 1 full plant per 3 or 4 students)
Small pieces of rubber tubing (slightly smaller than stem or branch diameter of plant)
Pipettes (5 ml plastic or glass - 2 if demonstration or 1 per student or small group)
Flat pan(s) (9x12 or larger; dissecting pan or dishpan will do)
Desk lamp(s) (any source of illumination)
Razor blades (sharp)

Procedure

1. Holding the plant under water, cut the stem off without crushing. If plant is large, cut a branch off in same manner. Cut end should remain in water.
2. Holding a short (about 3 in) piece of rubber tubing under water, insert cut end of plant firmly into tubing. Rubber

tubing diameter should be slightly smaller than stem or branch diameter. Leave tubing and cut end of plant in water.

3. Immerse pipette in water and insert tip firmly into free end of rubber tubing.
4. With setup still in water, squeeze rubber tubing gently to expel air bubbles.
5. Hold pipette in horizontal position and lift out of water. Place pipette on a flat surface. Secure plant in upright position in good source of light. (Suggestion - put pipette and plant in dry dissecting pan and tape plant to the side in an upright position, but be careful not to crush the plant or cover any leaves.) Optional: Put another plant setup in front of a fan and give it access to the same amount of light as other plant.
6. Record the position of the water column in the pipette every 15 min. (It may take 2 hr for the water level to change substantially. You may want to set the experiment up in advance or have another exercise for the students to work on during this time.)
7. Calculate rate of water uptake in ml/hr.
8. Optional: After transpiration is well established, move plant to a dark area and continue to record the uptake of water. Allow 15-min equilibration time.

Results

Have students record results as follows:

	Uptake of water (ml/hr)
Plant in light	
Plant with light and fan	
Plant in dark	

Questions

1. What is transpiration? Ans. Loss of water vapor (evaporation) from stems and leaves.
2. What are some external factors, illustrated by the experiment, that affect the rate of transpiration? Ans. Light and wind increase the rate of transpiration.
3. Why do these factors affect transpiration? Ans. Wind increases the rate of transpiration because more air is moving across plant surfaces, so there is more air available to take up water vapor. (Compare this to how a hair dryer works.) When more light is available, the rate of photosynthesis increases, causing an increased demand for CO_2. The stomata tend to open under low CO_2 levels, thus allowing more water vapor to escape.

R. Control of Pollen Germination, Tube Growth, and Cytoplasmic Streaming

David T. Webb, Department of Biology, Queens University, Kingston, Ontario, and David E. Bilderback, Botany Department, University of Montana, Missoula, MT

Purpose: To test the effects of actinomycin-D (inhibitor of RNA synthesis), cycloheximide (inhibitor of protein synthesis), colchicine (inhibitor of microtubule assembly), and cytochalasin B (inhibitor of microfilaments) on *Impatiens* pollen tube germination, growth, and cytoplasmic streaming.

During pollen development in the anther and following pollen germination, a sequence of biochemical and physiological processes occurs, which results in the growth of the pollen tube, formation of the male gametes, and ultimately double fertilization of the egg and the central cell. When pollen lands on the surface of a receptive stigma, it encounters a stigmatic fluid that contains inorganic and organic molecules necessary for pollen germination. Some of the factors like boron, potassium and calcium are necessary for germination and tube growth, and these have been included in the germination medium used in these experiments. The stigma also may produce sucrose that may be required for the metabolism of the growing pollen tube. *Impatiens* pollen does not require sucrose and this has been omitted from the culture media. Specific proteins that serve as recognition factors for germination are present on the pollen and the stigma. However, pollen will germinate in culture even though the stigmatic recognition factors are not present. At various stages during pollen development, DNA, RNA, and protein synthesis occur and are necessary for complete growth and differentiation. Also, the growth of the tube is dependent on the directed deposition of vesicles at the tip of the pollen tube. This secretory activity is associated with active cytoplasmic streaming. Microtubules and microfilaments are important cytoplasmic organelles that play a critical role in cytoplasmic streaming and secretion.

Materials

Microscope (10X)
Glass slides
Impatiens flowers (can also use Thanksgiving or Christmas cacti or other flowers as available - try it first if substitution is made)
Actinomycin D - Sigma Biochemical A4262 (2 mg/$13.75)
Cycloheximide - Sigma Biochemical C6255 (1 g/$2.90)
Colchicine - Sigma Biochemical C9754 (100 mg/$7.90)
Cytochalasin B - Sigma Biochemical (1 mg/$9.35)
Complete pollen germination medium (0.1% boric acid; 0.001-M $CaCl_2$, 0.0001-M KH_2PO_4 pH 6.2)
Control media 0.1% boric acid medium pH 6.2
0.001-M $CaCl_2$ medium pH 6.2
0.0001-M KH_2PO_4 medium pH 6.2

Procedure and Results

1. Each student will germinate pollen in a complete pollen germination medium (0.1% boric acid; 1×10^{3}-M $CaCl_2$; 1×10^{-4}-M KH_2PO_4 pH 6.2). This will be called medium (A).

   Each student will also germinate pollen in one of the following media.

Media Designation	Media Composition
B	Control medium - Boric Acid
C	Control medium - $CaCl_2$
D	Control medium - KH_2PO_4
E	Control medium + Actinomycin D (25 g/ml)
F	Control medium + Cycloheximide (1 x 10^{3} M)
G	Control medium + Colchicine (1 x 10^{4} M)
H	Control medium + Cytochalasin (25 g/ml)

2. Each participant should obtain 9 clean microscope/slides and cover slips plus 1 *Impatiens* pollen organ with visible colored pollen. (In class, each student does 1 control + 1 test solution.)
3. Use a marker to label the slides A-H.
4. Place 2 small drops of the correct medium on each slide.
5. Dip the pollen organ (fused stamens) several times in the control medium.
6. Use the same pollen organ and repeat the above with one test substance. It is imperative that the pollen first be placed in the control medium. Failure to follow this sequence will ruin the experiment.
7. Use a new flower for each additional experimental medium.
8. Record the exact time of inoculation in Table 1.
9. Use a 10X objective to observe germination of both cultures during the first 5 min. If interesting events occur in your experimental culture, let your partners observe them. After 10 min, record the percentage of germination in each culture for a random sample of 10 pollen grains in Table 1.
10. With a 10X-objective, use the optical micrometer to measure the length of 10 randomly selected pollen tubes from your control and experimental cultures. Enter these values in Table 2. Consult your laboratory instructor and convert these units into micrometers. Record in Table 3 the average tube length in micrometers for each of your treatments and those of the class.
11. Enter in Table 4 your data and class data for average percent pollen germination.
12. In pairs, take both of your control cultures, or start new ones, and observe them, one at a time, with the phase microscope set up by your lab instructor.
13. Find a tube with active cytoplasmic streaming. Observe for 1 min; then apply a drop of cytochalasin B to the side of the coverslip. What happens to the cytoplasmic streaming after cytochalasin B application?
14. Follow the same procedure, but use colchicine this time.

Questions

1. Is RNA synthesis required for Impatiens pollen germination and early tube growth in vitro?
2. Is protein synthesis required?
3. Are microtubules or microfilaments or both required for tube germination, growth, or cytoplasmic streaming?
4. What effects would you expect inhibitors of DNA synthesis to have on these processes?

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Teacher's Methods

All chemicals are available from SIGMA Chemical Co., P. O. Box 14508, St. Louis, MO 63178.

All are water soluble except cytochalasin B. Cytochalasin B must first be dissolved in a small volume of dimethylsulfoxide (DMSO). The final DMSO concentration should be 0.5-1%. A DMSO-only control in complete medium could be tested.

Optical micrometers and stage micrometers are available from most scientific supply houses like Carolina Biological, Fisher, and Scientific Products.

Pollen germination is sensitive to pH and sucrose concentration.

Germination is inhibited at acid pH and probably is inhibited at very basic pH. A pH study of germination makes a good project. Pollen germinates in 5% sucrose, but is inhibited at 10% and higher concentrations. Testing different sucrose concentrations and different carbohydrates also provides a good extension of this lab.

Impatiens seeds can be purchased from Burpee Seed Co., Warminster, PA 18991. Variety Sultani should work well. Flowers are ready when highly colored pollen is released from stamens. Mature flowers store well for 1-3 days refrigerated in plastic bags; after 3 days, viability decreases and results become erratic.

S. Reactions of Land Isopods to Light and Humidity

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Purpose: To study the orientation of organisms to light and humidity gradients.

Pill bugs demonstrate negative phototaxis. They have light receptors (ocelli) that are sensitive to general illumination (non-image forming) and make directed movements away from areas of greater illumination toward dark areas. Pillbugs are classic examples of animals orienting to humidity gradients via kinesis (more specifically, orthokinesis), or a change in the general level of locomotory activity with a change in the stimulus intensity. Stress that orientation via kinesis is due to a nondirected locomotor activity. Pill bugs increase their locomotor activity under dry conditions and wander quite randomly and decrease their activity under preferred humidity conditions. Because of this decrease in activity in areas of high humidity, pill bugs tend to accumulate or aggregate in damp places.

Materials (per student)

10 Isopods (pill bugs)
1 Aluminum tray (dissecting tray)
2 Pieces of paper
2 Ice cream tops or small paper box with notches cut in them
Squares of filter paper
Aluminum foil
2 Plastic boxes (or clear plastic cups) with notches cut in them

Procedure

1. Place a moist paper under the first paper box at one end of the tray and dry paper under the second paper box at the other end of the tray. Illuminate the tray as evenly as possible with the light source. Introduce the 10 animals to the center of the tray and allow them to wander for 30 min. If time permits, observe the animals during this period and record the number of exits from each box. At the end of 30 min, record the number of animals that are still wandering and the number under each box.
2. Repeat the above experiment, but cover the tray with aluminum foil so that the animals are entirely in the dark. Record results at the end of 30 min.
3. Place a moist paper under a clear plastic box and a dry paper under a paper box. Record results at the end of 30 min.
4. Place the dry paper under both plastic and paper boxes. Record results at the appropriate time intervals.
5. Place wet paper under both plastic and paper boxes. Record the results at the end of 30 min.

Return the isopods to the plastic container with moistened paper at the conclusion of the experiment.

Questions and Discussion

What do you conclude about how isopods react to both light and humidity?

Taxis means direct orientation of the organism in respect to a stimulus. *Kinesis*, used by Frankel and Gunn, indicates variation in intensity of locomotor activity, which is dependent on intensity of stimulation and not on the direction of stimulation.

From your observations, do pill bugs show taxis or kinesis with respect to light and humidity? What causes the pill bugs to wander? Which is the stronger stimulus - light or dryness? How do the animals aggregate on one paper or the other? Where would one expect to find these animals in nature? What types of receptors are we testing in this experiment?

Rationale for Experimental Setup and Expected Results

1. Two opaque boxes present choice of high humidity vs. low humidity with the animals initially exposed to light.
   Results: More animals should be moving at beginning (because of light stimulation). The amount of movement should decrease under the box with moist paper, hence, pill bugs will aggregate there. More animals should exit from the dry box than the moist box.
2. Same as above except everything is done with no illumination.
   Results: The total amount of movement will not be as great as in condition #1 but, with time, the pill bugs should aggregate under the moist box.
3. Testing whether light or humidity is a stronger stimulus.
   Results: There will probably be more pill bugs under the dry, opaque box than the wet, transparent box because the response to light is a taxis (directed) whereas the response to humidity is a nondirected change in locomotion or kinesis.
4. Response to light alone.
   Results: There should be a greater aggregation of pill bugs under the opaque box but the differences in condition #5 (under Procedure) will not be as marked as in condition #4 since the high humidity tends to suppress locomotion.

T. Regulation of Circulation Rate in Daphnia

M. A. Allan and C. K. Wagner, Biology Program, Clemson University, Clemson, SC

Purpose: To show how the hormones, adrenaline and acetycholine, can influence the heartbeat of the crustacean, *Daphnia*.

Most organisms with circulatory systems can adjust the speed at which materials circulate through the system in order to respond to the activity of the organism. In organisms with hearts, this is done by speeding up or slowing down the heartbeat and is controlled by hormone levels in the system itself.

Materials

Daphnia (Carolina Biological Supply, L565 Class of 50/$5.25)
Petroleum jelly
Culture media
Adrenaline solution (Caroline Biological Supply, 84-2092, $3.00)
Acetycholine solution (Caroline Biological Supply, 84-1611, 4 oz. $2.50)
Lamp
Culture dish
Cold culture media (0-5°)

Factors Influencing Heart Rate in Daphnia

Part 1: Immobilization of Daphnia

1. Place a small amount of petroleum jelly on the bottom of a culture dish and cover it with water.
2. Using a large-bore pipette, transfer a *Daphnia* to the culture dish.
3. Carefully remove the water so that the *Daphnia* becomes attached to the petroleum jelly.
4. Cover the preparation with water.

Part 2: Effect of Temperature Changes

1. Immobilize a *Daphnia* as explained in Part 1.
2. Determine the "normal" heart rate of a *Daphnia* in its culture water by counting the heartbeats for 3 consecutive min and then dividing the total number of beats by 3 in order to obtain the average heart rate. Record this value in the table provided. Also determine the temperature of the water and record it in the table.
3. Remove the culture water and add water that is between 0° and 5°C. Record the temperature. Determine the heart rate and record it in the table.
4. Place the culture about 1 foot from a lamp in order to gradually raise the temperature of the water until it reaches room temperature. (If the water heats up too rapidly, move it further from the light source.) Count the heartbeat at every 2° to 3° rise in temperature. For each interval, record the temperature and the heart rate in the table.

Temperature	Heart Rate

How do you explain your results?______________________________

Part 3: Effect of Hormones on Heart Rate

a. Influence of Adrenaline

1. Immobilize the Daphnia as explained in Part 1.
2. Determine the normal heart rate and record at zero time in the table below.
3. Gradually add several drops of adrenaline to the culture water.
4. Determine the heart rate each min for 5 min and record these values in the table below.

Time	Heart Rate
0	
1 min	
2 min	
3 min	
4 min	
5 min	

How do you explain your results?______________________

b. Influence of acetylcholine

Repeat with acetylcholine as for adrenaline above.

U. The Biochemistry of Macromolecules

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NOTE TO TEACHERS: The lab experiments given in this exercise are meant to accompany a unit on macromolecules and to be used as separate exercises as time permits.

Purpose: To explore some of the many colorimetric tests that can be used to identify the many types of biochemical macromolecules.

Lipid	Carbohydrates	Nucleic Acids	Proteins
Safflower oil	Glucose	RNA	Albumin
Crisco oil	Sucrose	DNA	
	Starch		
	Fructose		
	Ribose		
	Maltose		

Water will be included among the materials to be tested. Why do you think this is necessary?

Students will test for the presence of double bonds in fat molecules. What does "rich in polyunsaturates" mean? Students will distinguish among aldehyde and ketone sugars, monosaccharides and disaccharides, reducing and nonreducing sugars.

Students will learn how to identify DNA, RNA, and protein in solution.

Materials

I. **Hanus iodide test** - to test degree of fatty acid saturation

To saponify fats:

1. Place 100 ml triethylene glycol in a 500-ml flask.
2. Add 11.5 g KOH.
3. Add 50 ml of oil or 50 g of solid lipid.
4. Heat in water bath (@ 80°C) until 2 layers are formed and KOH has dissolved.
5. Cool to room temperature (use cold water).
6. Add 250 ml distilled water to flask.
7. Acidify by adding conc. HCl until solution turns red with litmus paper (need @ 25 ml). Stir with glass rod while adding.
8. Remove top layer (solid or oil) and save in beaker.
9. Add 50 ml chloroform to approx. 50 ml of top layer, stir and let stand until 2 layers are formed.
10. Place in separatory funnel and separate the bottom layer which contains the fatty acids for the Hanus iodide test.

Hanus iodide - Fisher SO-I-98 Iodine Solution, Hanus 500 ml/$10.10

or

Dissolve 13.2 g I_2 in 1,000 ml glacial acetic acid using gentle heat. Cool to 25°C. Add 1.5 g Br

Sudan IV - general test for lipid
0.1 g Sudan IV/100 ml 100% ethanol (Fisher S-667 25 g/$6.90)

II. **Carbohydrates**

1. 2% solution of glucose, sucrose, maltose (make sure maltose is reagent grade, Fisher M-75, 100 g/$8.30), starch (boiled), ribose, fructose

2. **Reagents**
Anthrone - Keep in dark bottle (lasts 2-3 days only); store in refrigerator.
950 ml H_2SO_4
50 ml H_2O
2 g anthrone (anthrone Fisher A-836, 25 g/$18.40)

3. Seliwanoff's - Store in dark bottle (keeps 1 week - refrigerate).
500 ml conc HCl or 50 ml
500 ml dist H_2O or 50 ml
0.5 g resorcinol or 0.05 g R17 100 g/$11.95 Fisher Resorcinol

4. **Benedict's** - Carolina Biological Supply. 84-6623 16 oz/$4.40

5. **Barfoed's I** - Store in dark; make fresh each yr.
Dissolve 24 g copper acetate (Fisher-cupric acetate - C-437, 500 g/$21. in 450 ml boiling H_2O.
If precipitate forms, do not filter. Immediately add 25 ml 8.5% lactic acid to hot solution. Shake, and nearly all precipitate dissolves.
Cool, dilute to 500 ml, and after sedimentation, filter out impurities.
Lactic acid:

Sigma Chemical 1250	or	Fisher A-162
100 ml/$1.30		500 ml/$16.20

6. **Barfoed's II** - Store in dark; make fresh each yr.

Copper sulfate (cryst)	18 g
Sodium carbonate	200 g
Sodium citrate	200 g
Potassium thiocyanate	125 g
Potassium ferrocyanide (5% solution)	5 ml
Distilled H_2O to make total value of	1,000 ml

Dissolve carbonate, citrate, and thiocyanate in approx. 800 ml distilled water with aid of heat.
Dissolve $CuSO_4$ in @ 100 ml distilled H_2O separately and pour into other liquid slowly with constant stirring. Add ferrocyanide solution, cool, and dilute to 1 liter.

7. IKI - Dissolve 2 g potassium iodide (Fisher P-410 100 g/$6.50) in 25 ml dist. H_2O. Add 0.6 g iodine (Fisher I-37 100 g/$7.20). Stir until dissolved. Bring up to 400 ml with dist. H_2O. Store in dark bottle. (shelf life 2 yr or more)

8. Orcinol - Fisher 0-244 10 g/$11.35
   1. 5g $FeCl_3$ to 1,000 ml conc. HCl
   2. Prepare fresh before use: 0.1 g orcinol + 10 ml $FeCl_3$ solvent

III. **Albumin Stock** 0.05 g albumin. Use bovine serum albumin (Sigma A4378 1 g/$5.25; store in freezer) to 100 ml distilled H_2O.

Protein Stock - 10 ml Albumin stock to 90 ml distilled H_2O

Protein solution for tests - 10 ml protein stock + 90 ml distilled H_2O (Fisher egg albumin A-388 100 g/$5.65 - worth trying)

Coomassie Blue - 0.1 g Coomassie Brilliant Blue to 50 ml 95% ETOH
100 ml phosphoric acid
Make up to 1,000 ml.
Coomassie brilliant blue G250
Fisher 0-2000 5 g/$6.00

IV. 1. DNA standard - Store frozen; will keep a few yr.
   0.1 g DNA to 200 ml distilled H_2O (place 1 drop glacial acetic acid to every 200 ml) - may need to heat to get into solution

2. RNA standard - Store frozen; will keep a few yr.
   0.1 g RNA to 200 ml distilled H_2O (place 1 drop glacial acetic acid to every 200 ml) - may need to heat to get into solution

   Sigma Chemical Co.
   DNA D1626 250 mg/$4.00
   1 g/$11.00
   RNA R6626 25 g/$2.00
   or
   Fisher (pretty impure - have never used these but could try)
   DNA (sodium salt) 11453 25 g/$8.65
   RNA 10010-P 500 g /$0.65

3. Diphenylamine - Fisher 0-2611 100 g/$14.50
   1. Dissolve 15 g diphenylamine in 1,000 ml glacial acetic acid (use new bottle).
   2. Add 15 ml concentrated H_2SO_4 (new bottle).
   3. Store in dark bottle.
   4. On day of use, add 1 ml acetaldehyde (Fisher 0-1004 250 ml/ $10.10 - keep in fire cabinet) solution (1 ml acetaldehyde to 500 ml distilled H_2O) per every 100 ml diphenylamine.

Exercise 1. Colorimetric Identification of Lipids

Purpose: To test for the presence of a lipid

Sudan IV in alcohol or acetone solution stains fats, oils, and some closely related chemical substances such as cutin.

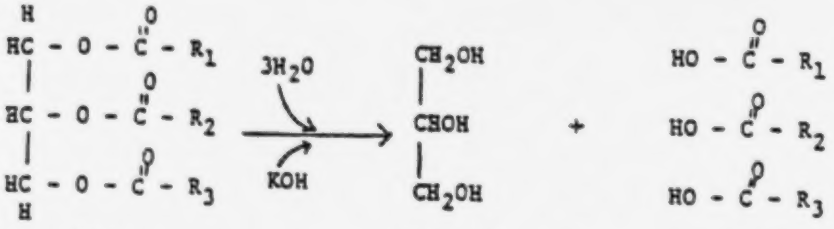
1. Place a small amount of crisco oil in a test tube. Tilt the tube and allow 2-3 drops of Sudan IV to run down the side. Does it float on the oil or sink beneath it? Why?
2. Shake. Add an equal amount of water down the side of the tube. Set aside to separate. When the separation is complete, where is the red color found?

Exercise 2. Testing for the Degree of Unsaturation of Fatty Acids (Work in pairs.)

Purpose: To be able to identify the presence of double bonds in fatty acid chains.

On the demonstration table, you will find 2 Erlenmeyer flasks containing the saponified lipids safflower oil and liquid butter. These were saponified by heating to 160°C for 20 min with KOH and triethylene glycol. After adding water and adjusting to an acid pH, two sharply defined layers result. The fatty acids are on top, and the glycerol fraction is on the bottom. You are to determine the degree of unsaturation (number of double bonds) in the fatty acids.

Separation of Lipid Into Its Component Fatty Acids



Fat Glycerol + Fatty Acids

The formula above is a generalized formula for the breakdown of fats. Not all lipids can be hydrolyzed into fatty acid and glycerol components. Lipids that can be separated into fatty acids and glycerol are called saponifiable lipids. These exist in many forms, including the neutral lipids often called fats or triglycerides and such forms as phospholipids, sphingolipids, glycolipids, and waxes in which the glycerol component is replaced by phosphoryl choline, one or more sugar residues, or an alcohol. Steroids and terpenes, also types of lipids, cannot be hydrolyzed into fatty acids and glycerol, and are called nonsaponifiable.

1. Label 2 test tubes with S for safflower oil and B for liquid butter. These 2 fats to be tested have already been saponified.
2. Add 1 ml of chloroform to each of the tubes. Make sure the tubes are dry.
3. To each tube, add 1 drop of Hanus iodide solution. The contents of each tube should turn the same color of pink.
4. Using a Pasteur pipette, carefully remove some fatty acid material from the top layer in each of the 2 Erlenmeyer flasks on the demonstration table.
5. Add 2 drops of fatty acids from each flask to one of each of the corresponding test tubes. Mix and set aside in a test tube rack. Make sure your tubes are labeled!
6. After 10 min, observe the color changes in each tube.
7. The greater the degree to which a fatty acid is unsaturated, the more it will decolorize the Hanus iodide solution. Based on this information, which product is more highly saturated?
   What does it mean to say that a fat is polyunsaturated?

Exercise 3. Identification of Carbohydrates

Many colorimetric tests exist to distinguish among monosaccharides, disaccharides, pentoses, hexoses, aldoses, ketoses, etc. Use the carbohydrates listed below to determine which colorimetric test is specific for each carbohydrate or class of carbohydrates.

	Chemical Structure	Description (be complete)
1. Glucose		
2. Sucrose		
3. Starch		
4. Fructose		
5. Ribose		
6. Maltose		

The tests you will be using are as follows: Anthrone, Barfoed's, Seliwanoff's, Benedict's, and IKI.

Many of the reagents to be used in these tests are strong acids. Be careful! Your lab instructor will give directions concerning the location of repipettes (pipetting devices used to repetitively deliver a fixed amount of liquid) containing caustic reagents.

Record color changes for carbohydrate tests in the chart on page 92. Be sure to record color and the presence of any precipitate.

- Anthrone Test (CAREFUL - Contains concentrated H_2SO_4)

  1. Using a Pasteur pipette, place 8 drops of carbohydrate solution into a test tube. Perform this test on each of the 6 carbohydrates and water, so you should have 7 tubes.
  2. Add 2 ml anthrone reagent to each tube. Immerse tubes in cold water while adding this reagent.
  3. Place in boiling water for 1-2 min.
  4. Record the color change on the preceding chart.

  Anthrone is a general test for carbohydrates. Anthrone reacts with carbohydrates in the presence of H_2SO_4 to give a blackish color. The color may vary somewhat from one carbohydrate to another, but anthrone reacts with all classes of carbohydrates.

- Barfoed's Test
  1. To each of 7 test tubes, add 1 ml Barfoed's Reagent I.
  2. Using a Pasteur pipette, add 8 drops of carbohydrate solution to each of 6 tubes and water to the 7th.
  3. Place in boiling water for 3 min only.

4. Record the color change in each (and note the time of appearance and color of any precipitate).
5. Let cool for 2 min.
6. Add 1 ml of Barfoed's Reagent II.
7. Note disappearance of any precipitate and any changes in color. Compare to control.

Barfoed's is a copper reduction test. Carbohydrates possessing a free or potentially free aldehyde or ketone group can readily reduce the ions of certain metals. In Barfoed's reagent, cupric acetate reacts with lactic acid to form a soluble complex copper ion that can then dissociate to yield sufficient cupric ions of the metal for reduction to cuprous oxide by reducing sugars. Cuprous oxide appears as a yellow to red precipitate.

Barfoed's is a general test for monosaccharides, but under proper conditions of acidity, disaccharides also respond. A positive test result includes the development of a bluish color (different from that of the water control) and the presence of a red precipitate. Disaccharides that are hydrolyzed by heat and acid conditions may also turn the solution to a color different from that of the control and result in the formation of a precipitate that may vary from white to red in the case of degradation to monosaccharides by the heat and acid. The whitish precipitate in solutions containing disaccharides or polysaccharides disappears with the addition of ferrocyanide contained in Barfoed's Reagent II. The red cupric oxide precipitate formed in the presence of monosaccharides does not disappear when Barfoed's Reagent II is added.

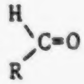
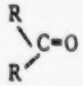
Note: Barfoed's can also be used as a test for reducing sugars as in Benedict's test (see next page), but with the modification employing the use of Reagent II, we can also distinguish between monosaccharides and di- or polysaccharides.

o Seliwanoff's Test

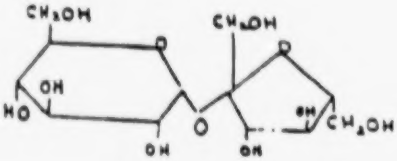
1. Add 3 ml of Seliwanoff's reagent to each of 6 test tubes.
2. Add 10 drops of carbohydrate solution to each tube.
3. Place in boiling water for 2 min only.
4. Record the color change in each tube. Be as specific as possible.

Seliwanoff's reagent tests for the presence of ketohexoses. Seliwanoff's reagent contains resorcinol, which is capable of reacting with a 6C compound containing a ketone group to produce a dark red precipitate. Thus, the positive test for the presence of a ketohexose with this reagent is the presence of a red precipitate.

- **Benedict's Test**

  Benedict's test is a test for reducing sugars. A carbohydrate with a free or potentially free aldehyde  $\mathrm{H}\diagdown\mathrm{C{=}O}\,/\,\mathrm{R}$ or ketone  $\mathrm{R}\diagdown\mathrm{C{=}O}\,/\,\mathrm{R'}$ group is classified as a reducing sugar because in solution of sufficiently high pH, these sugars can reduce weak oxidizing agents such as cupric or silver compounds and ferricyanide. The sugars are oxidized in the process to acids.

Any carbohydrate that can yield a free carbonyl linkage (C=O) that could be further oxidized is termed a reducing sugar. All monosaccharides are reducing sugars, as are most disaccharides. Sucrose is an exception to this. Sucrose is composed of -D-glucose and -D-fructose. Sucrose is shown below.



SUCROSE

The α, β (1-2) glycosidic bond in sucrose involves the anomeric (asymmetric) hydroxyl of both monomers, so there is no free aldehyde or ketone group. Since a free carbonyl group cannot be formed without breaking the glycosidic bond, sucrose is a nonreducing sugar.

Starch, a homopolymer of glucose, can be hydrolyzed to dextrin and glucose compounds on prolonged heating. These compounds will then give a positive result for reducing sugars.

Care should be taken when using Benedict's reagent to note the time of color change and appearance of a precipitate. Glucose, for example, rapidly reacts with copper sulfate in Benedict's reagent to form a red precipitate of cuprous oxide. (Copper sulfate ionizes in water such that cupric or Cu^{+++} ions are available for reduction to cuprous or Cu^{++}.)

Actually, the color of the precipitate ranges from green to reddish-brown depending on the quantity of reducing sugar present. Test each of the 4 carbohydrates to determine which is a reducing sugar.

1. Place 5 ml Benedict's reagent in each of 7 test tubes.
2. Add 8 drops of carbohydrate solution to each labeled test tube.
3. Heat the contents in boiling water for 3 min and then allow to cool.
4. Record the color and appearance of precipitate for each carbohydrate.

- IKI Test

  A solution of iodine and potassium iodide is used to test for the presence of starch. A dark blue color is formed if starch is present. As starch is hydrolyzed to dextrins and then to glucose by prolonged heating or enzymatic digestion, a brown to yellow color develops.

  1. Place 8 drops of carbohydrate solution in each of 7 test tubes.
  2. Add 1 drop of IKI.
  3. Record color change.

  Examine the structures and descriptions you have given in the chart on page 89. Without looking back at the descriptions of the tests you have used, combine the information from the results (and what you know about the sugars you tested) to determine just what each of the tests you used is designed for. Place this information plus the reasons for your conclusions in the chart below. Check to see that your conclusions agree with the descriptions of positive results for each test.

	Test For	Reason
Anthrone		
Barfoed's		
Seliwanoff's		
Benedict's		
IKI		

Exercise 4. The Colorimetric Determination of Protein and Estimation of Total Protein Concentration

Coomassie Brilliant Blue G-250 is a dye used in the textile industry to impart a blue color to fabrics. The dye complexes with protein-containing fibers, e.g., wool and other hair-based fabrics. Coomassie Brilliant Blue can change from a reddish-brown to a blue color in the presence of protein. The intensity of the color developed is dependent on the concentration of protein present.

1. Fill 1 test tube with 1 ml protein solution and a 2nd test tube with 1 ml H_2O.
2. Add 5 ml Coomassie Brilliant Blue reagent to each of the tubes.
3. Wait at least 3 min to observe color change.